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VOL. III of VII

A STUDY ON THE CONTROL OF GROUNDWATER HAZARD AT GAYS RIVER MINE

VOLUME III

OVERBURDEN DRILLING INVESTIGATION AND HYDROGEOLOGICAL ASSESSMENT GAYS RIVER MINE

By: Golder Associates Ltd.

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Golder Associates Ltd.
CONSULTING ENGINEERS

REPORT ON

OVERBURDEN DRILLING INVESTIGATION AND HYDROGEOLOGICAL ASSESSMENT GAYS RIVER MINE MILFORD STATION, NOVA SCOTIA

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EXECUTIVE SUMMARY

The Gays River Mine, owned by Westminer Canada Ltd. and located in central Nova Scotia, is an underground operation developed within a carbonate hosted, lead-zinc, massive sulphide orebody overlain by gypsum and anhydrite evaporite deposits. Karst weathering of the evaporites has created a deep zone of soil infill referred to as the "trench" which forms the hangingwall of portions of the orebody. The karst weathering along the gypsum margin of the trench is also associated with cavernous zones that, combined with permeable sections of trench soils, have resulted in a conduit for the large groundwater inflows to the mine, in the range of 4,000 to 6,000 USGPM.

Golder Associates Ltd. carried out a hydrogeological study of the site for Westminer that involved a surface drilling program and piezometer installations to determine the geological and groundwater conditions within the Pleistocene soil deposits and deeper trench deposits overlying the mine in order to asses their influence on groundwater contributions to the mine. The investigation also addressed the hydrogeological significance of the Gays River which flows across the overburden deposits above the mine.

The hydrogeological investigation, carried out during July and August 1991, established the soil stratigraphy as consisting of six laterally correlatable Pleistocene deposits overlying Cretaceous soils. The Pleistocene deposits include the Upper Lacustrine Clay and the Upper Sand overlying the Red Till (a clayey silt and sand deposit), which in turn overlies the Lower Lacustrine Clay, Lower Sand and Lower Till sequence. These deposits overlie the deeper Cretaceous sequence which includes sandy cavern infilling within karst gypsum and a relatively distinctive sequence of grey clay with interbedded units of quartz sand most commonly encountered within the deeper bedrock depressions associated with the trench zone. These latter deposits are referred to herein as the Cretaceous Clay and Cretaceous Sand respectively. The Cretaceous age of these deposits was established during previous investigations by Esso Minerals. Of the various soil units, the Upper Sand and Red Till were the most commonly encountered soil strata beneath the site.

Hydrogeologically, the Upper Sand, Lower Sand and Cretaceous Sand horizons form aquifers variously separated by the clayey Upper Lacustrine Clay, Red Till, Lower Lacustrine Clay, Lower Till and Cretaceous Clay aquitards. Due to the complex stratigraphic relationships between the soil units and the occurrence of overburden sinkholes within the mine area, the various aquifer strata are likely interconnected and locally in direct contact with permeable areas within the gypsum bedrock and the trench zone which drain to the mine.

Groundwater level monitoring has demonstrated that the mine drainage has developed a comparatively extensive drawdown cone and downward hydraulic gradients occur beneath most of the site. An assessment of the surrounding stratigraphy, structure and drainage has indicated that the total area of mine-related drawdown and hence the groundwater capture area may be in the order of 10km^2. The amount of precipitation-related recharge that may occur within this zone could potentially contribute annualized groundwater flows of approximately 1,000 to 2,000 USGPM to the mine.

The Gays River contribution to mine drainage was examined by the mine through an experiment conducted between July 25 and September 15, 1991 during a period of extremely low river flow. This involved the diversion of the mine discharge water (4,000 USGPM) away from the portion of the river passing the mine. The river base flow during the initial period of the diversion was approximately 500 to 1,000 USGPM. This flow entirely drained into the soil within the area of the mine drawdown cone following the diversion, resulting in the drying of the river bed. Therefore, at this time the river delivered at least 500 to 1,000 USGPM to the mine. Further, an examination of the mine pumping rate decline suggested that the total pre-diversion contribution from the river may have been 1,000 to 1,800 USGPM. These estimates are considered a minimum contribution during low flow periods when the river is confined to its channel. Flooding of the river during heavy rains is associated with increases in total mine pumping rates up to 6,000 USGPM which may result directly from increased infiltration through the inundation of the river flood plain.

The results of the investigation indicated that groundwater flow pathways occur within the soil deposits overlying the mine and that the river does contribute significantly to the mine infiltration, potentially accounting for 25 to 50 percent of the inflow. The river infiltration is considered to

largely occur in those areas where it flows over the Upper Sand unit and where potential downward groundwater flow pathways occur from the Upper Sand to the mine via sinkholes or direct contact with permeable bedrock. These permeable areas occur beneath the river to the north and northwest of the mine where the most notable decrease in river flow was observed during the diversion experiment.

The results of the study lead to the recommendation that mine dewatering could be enhanced through continuation of the successful underground drainhole development program. Further investigation of potential groundwater transmission along the trench zone, beyond the limits of this program, should also be undertaken to better assess the zone's contribution to mine drainage. Considering that river recharge appears to be significant, engineering modifications to the river channel to limit infiltration should be evaluated. Interception wells should also be considered at strategic recharge areas along the river to reduce both the underground mine pumping rate and the sensitivity of the mine to groundwater level fluctuations. The site should be continually monitored for sinkhole development, especially within the river area and any holes identified should be backfilled with clayey soil.

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1.0 INTRODUCTION

Golder Associates Ltd. was retained by Westminer Canada Ltd. in June 1991 to carry out an overburden drilling investigation at their Seabright Operation's Gays River Mine located at Gays River in central Nova Scotia (for location see Figure 1). The purpose of the investigation was to define the soil stratigraphy beneath the site, determine groundwater levels and assess the mine site hydrogeology and its influence on mine dewatering aspects.

The Gays River Mine is developed underground within a lead-zinc, massive sulphide orebody. The orebody is located along the contact between carbonate (foot wall) and gypsum/anhydrite (hanging wall) strata. Deep karst weathering of the gypsum/anhydrite and related infilling of granular soil material of Cretaceous to Pleistocene age has created a highly permeable environment within the hanging wall zone resulting in large groundwater inflows to the mine.

The scope of work for the overburden and hydrogeological investigation was developed by Golder Associates following a technical review meeting organized by CANMET on May 13th and 14th, 1991. The meeting was established to assist the mine with appraisal and remediation of the groundwater inflows and dewatering conditions. The meeting included an on-site and underground tour with mine staff, followed by a one-day discussion session. It was apparent as a result of this meeting that the overburden deposits above the mine and associated recharge through the overburden from the Gays River, were potentially major factors within the hydrogeological regime of the site. The investigation program, as initially established, was modified during the course of the investigation based on discussion with the mine staff, on conditions encountered and on results of additional drilling requested by Westminer as part of their internal review and assessment of site hydrogeology. In addition, the results of a mine water discharge diversion experiment carried out during the latter part of the summer were also assessed to evaluate the relationship between potential river recharge and mine dewatering.

The results of the drilling investigation, including borehole drilling and piezometer installation procedures, borehole records, hydraulic conductivity testing, water level monitoring, surveying and laboratory soil testing were previously presented in a factual report titled "Overburden Drilling Program" dated October 1991 (Golder Associates Report No. 911-1726). The factual

report was subsequently incorporated into the present report as Appendices. The present report presents a detailed geological and hydrogeological interpretation of the site based on the present field investigations.

Previous reports on the site geology and hydrogeology conditions were reviewed during the development of the drilling investigation. These included the following:

Esso Mineral Resources Ltd., (D.M. McKee & P.J. Hannon)	- 1982 - The Hydrogeological Environment of the Gays River Mine
Jacques Whitford & Associates Ltd.,	- 1985 - Gays River Sand Exploration - 1990 - Gays River Overburden Stability Investigation - 1991 - Hydrogeochemistry Assessment of Mine Water, Gays River Lead Zinc Mine
Western Mining Corporation (G. Meyer)	- 1991 - Gays River Mine Dewatering and Water Inflow Prevention

Jacques Whitford & Associates Ltd. carried out an underground groundwater quality sampling program in the mine during June 1991 as part of the CANMET hydrogeological study. Their report discusses the chemical composition of the various water inflows and suggested potential sources of the inflows (Jacques Whitford & Associates Ltd., Project No. 7170, dated November 5, 1991).

Golder Associates recently completed a summary report entitled "Underground Dewatering and Stability Considerations, Gays River, Nova Scotia" (Golder Associates Report No. 911-1721, November 1991) which discussed the underground drainage hole drilling program carried out during the summer of 1991 and its effect on underground water levels within the mine.

This present report addresses the overburden aspects above the mine. It has been compiled with input and assistance from mine staff. Golder Associates extends their appreciation to the staff of the Gays River Mine for their assistance in providing crucial information and insight throughout the course of this investigation, and for their technical review.

2.0 FIELD INVESTIGATIONS

The field investigation program portion of the work scope was carried out between June and August 1991. A detailed description of the field investigation is provided in Appendix A and the reader is directed to this Appendix for a full appreciation of the program. A summary of the major components of the investigation program is provided below.

- **Drilling Program**

  A total of 35 boreholes were drilled at 28 locations (Boreholes GA-1A to GA-28B inclusive) throughout the site, as shown on Figure A-1 in Appendix A. Piezometers were installed in each of the boreholes to monitor groundwater levels. Detailed Records of Boreholes are provided in Appendix A.

- **Geophysical Logging**

  Natural gamma and apparent conductivity geophysical logging was completed in fourteen of the Golder Associates piezometers to enhance the stratigraphic interpretation. Natural gamma logging was also completed in the pre-existing site monitoring wells. The results of the geophysical logging are presented in summary logs in Appendix B.

- **Laboratory Soil Testing**

  Representative soil samples from the various soil units encountered were analysed for grain size distribution to characterize the various stratigraphic horizons. Moisture contents were also determined, while selected clayey soils were analysed for Atterberg limits. The results are presented in Appendix C.

- **Groundwater Level Monitoring**

  The Mine undertook an on-going water level monitoring program in the Golder Associates piezometers as they were completed as well as continuing their monitoring of the pre-existing monitoring wells. In addition, as part of the Golder Associates study of the effectiveness of the underground drainage hole development program, eleven underground hydraulic head monitoring points were established, associated with diamond drill holes and drainage holes (ref. Report No. 911-1721, November 1991). The results

of this on-going monitoring program, to the end of October 1991, are presented in Appendix D. All water level monitoring locations are shown on Figure A-1.

It should be noted that all elevations discussed in this report, including ground surface, stratigraphic horizons, water levels etc. are referred to the mine datum. (Mine datum elevation of 500.357 m is equivalent to mean sea level or geodetic datum).

3.0 REGIONAL SETTING

The following sections discuss the general site conditions, the Gays River drainage basin and the position of the mine within the regional geological setting. These aspects provide background to understanding the complex relationships of the site hydrogeology.

3.1 Site Description

The surface topography of the mine site, the location of the Gays River in relation to the mine and various site features such as buildings, roads, monitoring wells, the tailings pond and the extent of underground mine development are shown on Figure 2.

The topography of the area surrounding the mine is dominated by elliptical ridges of overburden and comparatively broad, flat areas of river flood plain. The elliptical ridges trend northwest to southeast and are approximately 400 to 600 m in length and 100 to 125 m in width. They form a gently rolling topography that varies in elevation from 515 to 560 m. Several of the ridges appear (based on their alignment) to be glacially derived drumlins, probably developed from the southeasterly migration of glaciers from the Minas Basin area during the last glaciation.

The flood plain of the Gays River ranges in elevation from approximately 514 to 516 m where it passes over the mine. The plain varies in width from approximately 50 to 300 m, the largest area of flood plain being within the north branch of the Gays River valley upstream of the mine site.

The general ground surface within the mine site itself varies in elevation from 515 to 535 m. A sand pit approximately 100 m in diameter has been developed near the centre of the site (see Figure 2). It extends to depths of approximately 20 m below ground surface where glacial till is locally encountered in the pit floor. The pit operators also reported that (carbonate) bedrock was locally encountered (personal communication). The elevation of the pit floor is approximately 514 to 517 m, locally extending about 1 m below river level.

The mine portal is located centrally within the sand pit and underground access is provided by decline ramps. The underground workings, including drifts and stopes, trend northeast-southwest and extend down dip to the northwest as indicated on Figure 2. Total development along strike extends approximately 1,500 m. The maximum depth of the mine is 129 m below river level within the 118 Sump area (ie. to an elevation of 386 m). The main underground dewatering stations within the mine are the centrally located 118 Sump at around elevation 400 m, the southwestern 803, 804 and 808 Sumps which vary in elevation from 416 to 427 m, and the northeastern 119 Sump at elevation 424 m. The approximate sump locations are shown on Figure 2.

The amount of groundwater discharged from the underground sumps ranges seasonally from approximately 4,000 to 6,000 USGPM. The water is discharged to the tailings pond located south of the mine, which then drains into the main branch of the Gays River approximately 1,000 m upstream of the mine access bridge (see Figure 2).

The mine was allowed to flood in 1982 and prior to being dewatered in 1989, the flooding was approximately at river level, (ie., to elevation 515 m). Under the present dewatered condition, the lower reaches of the dewatered mine workings are 115 to 130 m below the adjacent river level.

3.2 Gays River Drainage Basin

As shown on Figure 3, Gays River Mine is located near the downstream end of the Gays River drainage basin near the confluence of the North Branch Gays River (which passes over the mine) and the South Branch Gays River. The basin drains northwesterly toward the Shubenacadie River and thence to the Minas Basin of the Bay of Fundy. The elevation of the Gays River where it passes through the mine site is approximately 513 to 516 m or 13 to 16 m above sea level. The upland areas drained by the river vary in elevation from approximately 550 to 650 m (50 to 150 m ASL). The Shubenacadie River is affected by the Bay of Fundy tide near the confluence with the Gays River some 5 km to the northwest of the site.

The Gays River drainage basin has a total area of approximately 198 km^2, based on the area shown on Figure 3. The north branch of the river, which drains the area upstream of the mine, has an area of approximately 100 km^2. The South Branch which enters the main Gays River downstream of the mine, is smaller, draining approximately 53 km^2. The balance of the total drainage basin downstream of the two branches is approximately 45 km^2. The entire drainage basin has very few lakes other than Lake Egmont, a body of water approximately 1.5 km by 0.5 km which drains into the main branch of the Gays River upstream of the mine. As the river does not have any control structures and hence is unregulated, it responds directly to runoff events.

Environment Canada climatic norms for the region indicate that the basin receives an annual precipitation of approximately 1400 mm and experiences an evapo-transpiration loss of about 500 mm per year. Therefore the annual runoff (total precipitation minus evapo-transpiration) is approximately 900 mm per year. Based on these estimates, the average annual discharge from the North Branch Gays River, upstream of the mine would be of the order of 92 x 10^6 m^3/yr or 2.4 x 10^{10} US gallons per year. This discharge would represent the total combined river flow including both direct runoff and base flow provided by groundwater discharge. The actual discharge rates will be strongly influenced by events such as the spring runoff and periods of heavy rainfall.

Several stream gauging exercises have been carried out for the mine by Martec Ltd. of Halifax, Nova Scotia and a permanent gauging station was established at the mine entrance bridge over the north branch of the Gays River in April 1991. However, the mine had been keeping records of the river level at the bridge since 1989. Therefore, the stream flow could be back calculated.

The drainage basin area upstream of the gauge is approximately 94 km^2. The gauge measurements indicated that the river discharge past this point typically varies from less than 10,000 to about 225,000 USGPM seasonally. An abnormally high peak flow of 456,000 USGPM was recorded on Nov. 12, 1991 following a period of heavy rainfall. Being an unregulated stream with few large water bodies, the river was observed to respond rapidly to variations in precipitation. Under conditions of low to moderate flow during the drier seasons of the year, the

river remains within its channel. However, during periods of high flow (greater than 75,000 USGPM) during the Spring runoff and Fall rains, the river can extend out over its flood plain.

3.3 Geological Setting

The bedrock geology of the mine area is shown on Figure 4. The mapping is largely based on exploration drilling as outcrops are very limited due to the extensive cover of glacial deposits.

The oldest bedrock strata underlying the site are quartzite and greywacke of the Meguma Group, Goldenville Formation of the Ordovician Period. The formation is folded, highly indurated and resistant. It forms a northeast to southwest trending outlier along the southeast flank of the mine as shown on Figure 4. It is unconformably overlain by the Carboniferous Period, Windsor Group carbonates and gypsum/anhydrite evaporites of the Gays River and Carrolls Corner Formations respectively.

The Gays River Formation carbonates, principally dolostone, developed as a coral reef facies upon the erosional remnant of the Goldenville Formation and as such these rocks flank the sides of the quartzites as indicated in Figure 4. The carbonates are also resistant and combine with the underlying quartzite to form a northeast-southwest trending structural ridge separating the evaporite basins to the northwest and southeast.

The structural relationship of the ore zones within the bedrock and the overlying overburden deposits is shown schematically on Figure 5. The Carboniferous strata, including the carbonates and evaporites, are essentially flat-lying, upon the irregular, unconformable surface of the quartzite. The carbonates formed a steep faced coral reef on the margin of the evaporite basin. Sulphide mineralization, principally sphalerite and galena, was hosted within the carbonates along the contact between the carbonates and evaporites.

The gypsum/anhydrite along the carbonate and ore zone contact has undergone extensive karst weathering since the deposition of the orebody. This has created the "trench" on the hanging wall of some of the ore zones. The trench is a comparatively narrow, linear zone of karstic

caverning that is variously infilled with soil materials to depths of 40 to 110 m below river level, as indicated on Figure 5. The extent of the trench relative to the ore zone is shown schematically on Figure 6. A bedrock contour of the general mine area along with the approximate axis of the trench, both supplied by Westminer, is shown on Figure 7. The elevation contours shown on Figure 7 were developed by the mine, based on the combined results of extensive diamond drilling as well as the previous monitoring wells and recent boreholes. The contours show the area of deep bedrock depressions along the trench but are not likely fully representative of the actual trench zone configurations due to the limitations of bedrock drilling information. Several of the deep depressions indicated are actually continuous with one another, based on the underground mining experience.

The trench depression is infilled with a complex sequence of clays, sands and gravels. However, open voids and open cavity zones also occur within the adjacent gypsum.

Karst weathering of the evaporite rock is a on-going natural geological process within the area as regionally indicated by the development of numerous large and small sinkholes. The underground dewatering operations also appear to have initiated some sinkhole development within the mine site.

The principal areas of large groundwater inflow encountered by the mine are associated with the zones of karst caverns in the evaporites adjacent to the trench and the sand and gravel infills within the caverns as schematically indicated on Figure 5. The contact between carbonate and gypsum, where it has locally weathered, can also yield groundwater inflows, such as have occurred in the 119 area of the mines; however, where it is unweathered, the contact zone is dry. Mine development within the quartzite and unweathered carbonate has typically encountered only minor seepage, indicating that the rock is of low permeability. Developed areas of the mine excavated into unweathered gypsum and anhydrite are also essentially dry.

The overburden deposits comprising the trench infill and the extensive sequence of glacial sand and gravel outwash and till form a complex stratigraphic sequence of overburden aquifers and aquitards overlying the mine workings. The composition and stratigraphy of these soils, based on the present investigation, are discussed in detail in Section 4.

4.0 OVERBURDEN STRATIGRAPHY

The 1991 overburden drilling investigation identified several major, correlatable, stratigraphic soil horizons overlying the bedrock at the mine site. These soil horizons include both Pleistocene and Cretaceous deposits as well as thin alluvial (Recent) deposits related to the existing river. The soil stratigraphy is summarized in Table 1. The stratigraphic sequence is shown schematically on Sections AA to EE of Figures 8 to 10.

The Recent deposits consist of peat and clayey to sandy alluvium associated with the Gays River. These deposits overlie an extensive sequence of glacially derived Pleistocene deposits consisting of lacustrine clay, outwash sand and till.

The Pleistocene deposits appear to be subdivided into two distinct cycles, the Upper Lacustrine Clay, Upper Sand and Red Till and the underlying Lower Lacustrine Clay, Lower Sand and Lower Till. The two cycles may represent two distinct glacial advances within the Gays River area, the onset of the second advance being marked by the Red Till unit. Therefore, the base of the Red Till unit likely lies disconformably upon erosional surface of the earlier glacial period. Glacial deposits that underlie the Red Till are therefore designated as "Lower" as indicated on Table 1.

The glacial deposits in turn disconformably overlie distinctive deposits of interbedded clay and quartz sand. The age of these deposits, where encountered in the trench, was previously established as Cretaceous, based on fossil spore and pollen assemblage dating carried out by Esso Minerals in the early 1980's. Cretaceous deposits of this nature are known to occur elsewhere throughout the Musquodoboit Basin based on discussions with the mine geologist. Beneath the mine site, the Cretaceous clay and sand deposits and what may be Cretaceous sands and gravels most commonly occur within the bedrock depressions of the trench zone and associated infillings in cavernous karst zones. The deposits have some unique compositional features that distinguish them from the glacial deposits as discussed in the following sections.

Although several soil units have been identified within the stratigraphic sequence, they are never all encountered at any one borehole location. The occurrence of the various units intersected in

the 1991 Golder Associates boreholes is summarized in Table 2. The number of units encountered in individual holes varied from only one in the case of Red Till at Borehole GA-7, to as many as six units including the Cretaceous Clay and Sand in Borehole GA-27. The Upper Sand and Red Till were the most frequently encountered units. It was noted that the stratigraphic superposition of the various units remained relatively consistent although intervening horizons were absent.

The trench and associated cavernous karst zones are also infilled to varying degrees with Pleistocene-related sand and gravel. These deposits appear to have been emplaced through glacial gouging along the trench zone, and are possibly interrelated with zones of karstic cavern collapse, piping infills etc., and as such, they are difficult to assign to a unique stratigraphic horizon.

Understanding of the complex stratigraphic relationship of the soil deposits is essential to the hydrogeological evaluation of the site, both in terms of the water bearing nature of the soils and the vertical and lateral interconnection between horizons such as the Upper and Lower Sands and the bedrock.

A description of the composition and occurrence of each major stratigraphic unit, is provided in Section 4.1 below. The geotechnical characterization of these units, based on field examination and laboratory testing, is discussed in Section 4.2.

4.1 Stratigraphic Soil Units

The composition of individual soil horizons encountered in the various boreholes is described in detail on the Records of Borehole Sheets included in Appendix A. The following sections describe the origin, general composition and distribution of the major stratigraphic units as indicated from the borehole records.

4.1.1 Alluvium

The alluvium deposits occur beneath the flood plains of the major regional stream courses, including the Gays River and Black Brook. They are generally overlain by a thin surface layer

of peat comprised of dark brown organic fibre from marsh grasses, roots, decomposed organic silt and occasional pieces of wood interbedded with inorganic silt and clay of alluvial origin. Granular alluvial deposits of grey to brown clayey silt, clayey sand, sand and minor gravel also occur (eg. Boreholes GA-8A and GA-14A).

The bed of the Gays River channel is quite variable. In areas of comparatively slow flow, such as near the mine entrance bridge, the bottom comprises silt and sand. Downstream in the river section from Borehole GA-10 to past Borehole GA-9, the river bed consists of graded sand and gravel, while the broad flood plains generally consist of silty and clayey soils beneath marsh peat.

4.1.2 Upper Lacustrine Clay

This unit was encountered in Boreholes GA-2, GA-3, GA-11, GA-12, GA-15 and GA-19 where it varied from 2 to 7 m in thickness. It is comprised of soft to stiff, dark red brown, moist to wet, laminated, clayey silt to silty clay. Typical grain size curves are shown on Figure C-1 in Appendix C.

The unit is locally interbedded with silty sand, such as in Borehole GA-15, but the overall clayey character of the unit distinguishes it from the Upper Sand. Silt and fine sand commonly form lamination partings within the clay.

The upper surface of the clay unit occurs between elevations of 513 to 520 m while the base of the strata occurs at elevations of approximately 510 m to 516 m. The variations in elevation suggest that it was deposited during a previous period of higher water levels and that it drapes over a former, somewhat irregular topography. It does not occur on the higher ridges, indicating that its deposition was still largely controlled by the existing Gays River Valley. Much of the broad flood plain upstream of the mine is likely underlain by this clay.

4.1.3 Upper Sand

The mine sand pit is developed within the Upper Sand unit. The Upper Sand was one of the strata which were most frequently encountered during drilling. It varied in thickness from 2 to

40 m. The sand varies in composition from loose to very dense, light to medium brown, interbedded sandy silt to medium sand with some fine to medium gravel and a trace of silt. In general, the material is well sorted as shown by the grain size curves on Figure C-2.

The Upper Sand underlies the Mine Administration Building and the sand pit area and extends northwestward toward the river in the area of GA-14 and GA-15. The deposit extends westward downstream in the river valley towards the Village of Gays River where it underlies the river channel and also forms terrace deposits on the south shore of the river between Boreholes GA-9 and GA-10. The sand may also extend southward from the mine towards the tailings basin. The sand appears to form a discontinuous, valley-confined outwash deposit that is likely correlatable, but probably not directly connected with, the sand deposits upstream in the Cooks Brook area.

The Upper Sand deposits are potentially in direct contact with the underlying gypsum bedrock in the vicinity of Borehole GA-9 where the underlying soil deposits appear to be greatly thinning, as indicated on Section A-A, Figure 8. There is also a high potential that the development of cavern collapse within the underlying gypsum has also directly connected the Upper Sand with permeable zones within the gypsum. This is suggested by the sinkholes that have developed within the area of Borehole GA-9.

4.1.4 Red Till

The Red Till is a very distinctive unit comprised of hard, moist, massive-textured, medium to dark red brown, clayey silt and sand with some gravel. Cobbles and boulders occasionally occur. The grain size curves shown on Figure C-3, indicate the well graded nature of the material and the narrow range in composition between borehole locations. The Red Till is exposed in the base of the sand pit where it directly underlies the Upper Sand with a sharp contact. It forms elliptical drumlin ridges within the area, the alignment of which suggest that the till sheet was deposited by a southeasterly moving ice sheet. This would suggest the Cobequid Mountains as a possible source for the granitic, volcanic and metamorphic clasts within the till, and the Triassic sediments of the Minas Basin for the reddish colouration and clayey composition. Carbonate and gypsum clasts from the underlying bedrock are also common within the till.

The results of the drilling program indicate that the till is quite variable in thickness, ranging from less than 5 m up to 28 m. Previous drilling has indicated thicknesses of up to 50 m within the ridge overlying the southwestern half of the mine. The till can also contain minor thin interbeds of sand such as occurred in Borehole GA-2.

The till was encountered in most drilling locations but it was noticeably absent downstream of the mine at Boreholes GA-8, GA-9 and CA-10. Elsewhere, it either lies directly on gypsum bedrock or older soil deposits of Pleistocene or Cretaceous age as summarized on Table 2.

4.1.5 Lower Lacustrine Clay

The Lower Lacustrine Clay was encountered beneath the Red Till at Boreholes GA-6, GA-12 and GA-27 where it varied between 4 to 15 m thick. The clay strata is a hard, dark red brown, moist to wet, laminated, clayey silt to silty clay. Silt and fine sand form lamination partings. Typical grain size curves are shown on Figure C-4. The material is similar in texture and composition to the Upper Lacustrine Clay, except that it is more overconsolidated, likely due to glacial loading.

The thickest section of Lower Lacustrine Clay (13 m) was encountered in GA-27. The geophysical record of this hole (see Appendix B) indicates a distinct upward coarsening trend from silty clay to clayey silt. Occasional gravel size dropstones comprised of granites and carbonates occur toward the top of the clay. The dropstones likely reflect the onset of the Red Till event.

4.1.6 Lower Sand

The Lower Sand strata was encountered in several boreholes throughout the site. The most extensive occurrence of the sand appeared to be beneath Meadow Brook extending southward to the mine (Boreholes GA-12, GA-13 and GA-18). The sand varied in thickness from 2 m to 26 m, the thickest section being encountered in hole GA-13.

The Lower Sand is directly overlain by Red Till at Boreholes GA-13 and GA-18, while at Borehole GA-12 it is directly overlain by Lower Lacustrine Clay, which is in turn overlain by Red Till (see Section E-E, Figure 10). Lower Sand (ie. the sand underlying Red Till) was also encountered in Boreholes GA-6 and GA-27 where it forms a 2 m thick strata occurring at similar elevations in both holes. In this location, it lies between the Red Till and Lower Lacustrine Clay (see Section A-A, Figure 8). This sand may thus be a localized deposit of limited lateral extent.

The sand is a dense to very dense, light to medium brown to grey brown, wet, interbedded sequence of silty sand and medium to coarse sand with traces of silt and gravel. The sand is feldspathic like the Upper Sand and the gravel clasts represent a broad suite of lithologies including granites, volcanics and carbonates. Representative grain size curves are shown on Figure C-5. The sands are generally well sorted, similar to those of the Upper Sand strata. The Lower Sand tended to pipe into the drill stem where it was encountered beneath the water table, probably due to the higher water pressures encountered at depth.

4.1.7 Lower Till

The Lower Till was encountered in Boreholes GA-6 and GA-17. The till varies in thickness from 10 to 19 m respectively in these boreholes and it directly overlies the bedrock. It is hard, dark grey brown, moist, massive textured to faintly laminated clayey silt and sand with a trace to some gravel. The grain size curves indicate its well graded nature, as shown on Figure C-6.

The till is distinguishable from the underlying Cretaceous Clay unit (see Section 4.1.8) by its more massive texture, brownish coloration and the polymicitic lithology of the sand and gravel size clasts within it.

The clasts vary from subangular to subrounded quartz grains and pebbles of several lithologies including volcanics, quartzite, sandstone, carbonate, granite and gypsum, similar to the lithological suite within the Red Till. The Lower Till also contains distinctive traces of coarse sand to fine gravel size clasts, comprised of sand size quartz grains cemented by pyrite, as noted during an examination of the coarse material with a binocular microscope. These pyritic grains are typically associated with the underlying Cretaceous Clay unit which would be the probable

source.

4.1.8 Cretaceous Clay

The Cretaceous Clay is a very distinctive deposit, encountered in six boreholes (GA-9A, GA-9B, GA-10A, GA-15, GA-22A and GA-27) where it varies in thickness from approximately 2.0 m to 24.5 m. Previous drilling within the area indicates that it can vary in thickness up to 36 m (Well OW-2). The thickest deposits of the clay tend to occur within the deep bedrock depression forming the trench zone and adjacent areas of bedrock depressions such as at Borehole GA-10 (see Section A-A, Figure 8).

The material, where encountered in the boreholes, is a light to dark grey, typically laminated but occasionally massive textured, moist, clayey silt and sand with a trace to some gravel (see Figure C-7). It lacks the brownish colouration of the overlying glacially derived clayey soils. The sand and gravel size clasts within the clay are almost entirely subrounded quartz. Carbonate and gypsum clasts also occur.

Traces of angular quartz-pyrite clasts were encountered throughout the clay samples, being most numerous in Borehole GA-15. Microscopic examination indicated that the clasts are comprised of fine to medium grained subrounded quartz sand cemented with pyrite. The clasts varied in size from approximately 1 to 20 mm and were quite angular in shape.

Washing of the clay samples occasionally produced a black silt, possibly amorphous iron sulphide. Small fragments (1 to 5 mm) of black carbon, probably derived from wood, were also noted in the samples.

The grain size distribution and well graded nature of the Cretaceous Clay, as shown on Figure C-7, is very similar to that of the overlying tills. However, the laminated bedding, the predominantly quartz composition of the clasts within the material, and the lack of exotic clasts such as granites and volcanics typical of the overlying tills, suggest that it was derived locally. The top of the unit was encountered between elevations of approximately 494 to 502 m, representing a level that may have been associated with a former Cretaceous age drainage channel

or a series of ponds within the trench zone and surrounding evaporite sinkholes.

4.1.9 Cretaceous Sand

The Cretaceous Clay deposits contain interbedded layers of sand as shown on Section A-A, Figure 8. The sand is almost entirely comprised of subrounded quartz grains with occasional quartz-pyrite grains. It is a dense, light grey, well sorted, medium grained sand with a trace of silt and fine gravel (see Figure C-8). These sand layers were encountered at various depths in Borehole GA-10A and drill water circulation was lost within them indicating that they are quite permeable. The zones of water loss were correlatable with signatures on the geophysical record of GA-10A which indicated the thickness of the sand beds. The thickest section of sand (9 m) was encountered in Borehole GA-15 where the sand was apparently under some hydraulic pressure since it piped into the drill stem.

The sand horizon encountered between the Lower Lacustrine Clay and the Cretaceous Clay in Borehole GA-27 was distinguished as Cretaceous Sand based on its light grey quartz, quartz-pyritic composition, distinguishing it from the brown, feldspathic Lower Sand.

4.1.10 Cavern Infill

The karstic cavern infill material encountered within the gypsum in Boreholes GA-13 and GA-17 was found to be a light to medium brown, interlayered sequence of silt, silty sand, or silty sand with some gravel and cobbles. The pebble to cobble size clasts were a polymictic mixture of subangular to subrounded granite, volcanic, carbonate, quartzite and gypsum, similar to the overlying Pleistocene glacial deposits. The cavern infill material within the gypsum in Borehole GA-13 was overlain by Lower Sand strata whereas in Borehole GA-17 it was overlain by Lower Till.

Pebbles and cobbles discharged from the unscreened drainage holes that penetrate cavernous zones in the 118 Sump area included granites, volcanics, sandstones and carbonates representing a broad suite of lithologies, again considered similar to the glacial deposits. These clasts are likely derived from the karstic cavern infill deposits.

The age of the cavern infills within the gypsum encountered during this investigation is not known. However, the lithological composition of the clasts comprising the material differs significantly from the Cretaceous Clay and Sand deposits suggesting a different provenance for these deposits and possibly different geological times of deposition. The appearance and composition of the infill material encountered in the surface boreholes put down during this investigation suggests that the material is possibly Pleistocene in origin, but its composition does not preclude the potential for such materials being Cretaceous, as suggested by previous investigators.

The occurrence of possibly glacially derived materials at depth within the cavernous gypsum zones however, demonstrates the potential interconnectivity of these deep zones with the glacial overburden deposits. Material of this nature, as a result of on-going karst activity, would have been likely emplaced over a broad range of time extending from the initiation of glaciation right through to recent times. However, during the Pleistocene, sea levels and probably groundwater levels were much lower than at present. This may have allowed for deeper and more active circulation within the karstic gypsum zones, thereby potentially allowing more extensive emplacement of glacially derived deposits at depth.

4.1.11 Stope Deposits

A soil sample was collected from the hanging wall of Stope 841 West during the May 1991 underground inspection. The exposed soil was a dense, medium brown, massive textured sandy soil. The grain size distribution curve for the soil (see Figure C-10) indicates that it is a well graded silt and sand, some gravel. A microscopic examination of the soil indicated that the sand was micaceous quartz and feldspar similar to that of the Lower and Upper Sands. However, the gravel clasts were entirely an angular, carbonate cemented quartz sandstone suggesting that the deposit is not directly related to the overlying polymictic Pleistocene sand and gravel deposits.

A second underground inspection was carried out in August 1991 to specifically examine the soils exposed within the open stopes in an attempt to correlate them with the deposits encountered during the overburden drilling investigation. The soils examined were typically medium brown well graded, silt and sand some gravel, very similar to the Stope 841 sample.

Discussions with the mine geologist indicated that the majority of the soil exposed in the stopes has been of the brown, sandy to silty type encountered in the 841 Stope. The Red Till has also been encountered locally in the mine, as have more clayey units. Notably, during the August 1991 inspection, one sample of clay, similar in appearance to the Cretaceous Clay unit, was also encountered in the 101-1 heading.

4.2 Geotechnical Classification

4.2.1 Moisture Content

The moisture content of the various soil horizons was determined as part of the grain size classification work. The results are summarized on Table C-1.

The Upper and Lower Lacustrine Clays samples exhibit similar average moisture contents of 22.2 and 17.3 percent respectively. The fact that the Lower Lacustrine Clay moisture contents are slightly lower, probably reflects the higher degree of consolidation as discussed in section 4.1.5.

The moisture content of the Red Till fell within a narrow range of 8 to 12 percent, averaging 10 percent, typical of a well graded till. The Lower Till also had similar moisture contents.

The moisture contents of the Cretaceous Clay samples varied between 11 and 18 percent, averaging 14.7 percent, typically higher than the till samples (although of similar grain size distribution) and lower than the lacustrine clays.

The sand units have a broad range of moisture content reflecting grainsize and void ratio variations. Several sand samples including the Cretaceous Sands were noticeably wet when recovered.

4.2.2 Atterberg Limits

Atterberg Limits were determined for a representative suite of the clayey soil units as summarized on Table C-2. A plot of the liquid limit versus plasticity index (see Figure C-10) indicates that

the clayey soils are of low to moderate plasticity. The natural moisture content of these soils is generally below the plastic limit which is indicative of high undrained shear strength and high cohesive behaviour during excavation. By comparison, the sandy soils typically have a very low plasticity and will tend to flow under saturated conditions (eg. in excavations below the water table).

4.2.3 Hydraulic Conductivity

The hydraulic conductivity of the various soil units was evaluated by carrying out piezometer response tests and using Hvorslev methods of analysis (see Table A-4). The hydraulic conductivity of the sand units was also evaluated using the Hazen method, which is based on grain size. This method is applicable for well sorted sands such as those encountered at this site. The Hazen data are tabulated on Table C-3.

- **Clayey Soils**

  The clayey soils, where they do not contain significant sand layers, are associated with low hydraulic conductivities, in the order of 1×10^{-6} cm/sec or less. For example, response tests for piezometers entirely sealed within the Red Till produced hydraulic conductivity results in the range of 1×10^{-6} to less than 1×10^{-7} cm/sec. This is typical for a massive textured clayey soil. As such, the till would not pass significant quantities of water except where it is thin and fractured or actually breached by sinkhole development.

- **Sandy Soil**

  The sandy soils, including the Upper, Lower and Cretaceous Sands are generally quite permeable. The calculated hydraulic conductivities for samples of well sorted sands generally ranged between 1×10^{-2} to 1×10^{-5} cm/sec (see Table C-3). More than half of the samples were estimated to be in the 10^{-3} cm/sec range. One sample of Cretaceous Sand from Borehole GA-15 was estimated to be highly permeable (in the order of 1×10^{-2} cm/sec) due to the absence of any silt particle sizes.

A comparison of piezometer response versus Hazen method hydraulic conductivity results for the Lower Sand at Boreholes GA-12 and GA-18 indicates that the response test results are lower than the Hazen values. The response test results range between 2×10^{-4} to 7×10^{-5} cm/sec while the Hazen hydraulic conductivity values average 4×10^{-3} cm/sec. The Hazen results are specific to the individual samples tested whereas the piezometer responses likely average the influences of coarse to fine sands over the monitoring interval. Piezometer response tests are also very susceptible to the completion details of the individual piezometers whereby piezometers can straddle several zones of which generally one zone controls the permeability. Caving of material around piezometer screens can also greatly influence their hydraulic connectivity with respect to the in situ formations (see Section A.4.3 in Appendix A). In such situations, often the Hazen results, particularly for the sands, are more representative.

The hydraulic conductivity data obtained from the response tests and Hazen calculations provide a 'very approximate' quantitative indication of the permeability of the various strata and hence their potential to yield water. Based on this data and on the general character of the soils, the sand horizons are certainly the water-bearing horizons and thus comprise the principal overburden aquifers. Hydraulic conductivities in the order of 1×10^{-2} to 1×10^{-4} cm/sec can be anticipated for the sand deposits. A "rule of thumb" for evaluating hydraulic conductivity data with regard to well production suggests that 1×10^{-4} cm/sec would represent a yield of approximately 1 USGPM, while 1×10^{-3} cm/sec material would yield 10 USGPM and 1×10^{-2} cm/sec would yield 100 USGPM or greater. By this guideline, the sands within the upper range of hydraulic conductivities indicated are considered capable of transmitting significant quantities of water, on the order of 100's to 1,000's of USGPM relative to the scope of mine dewatering at the site.

By contrast, the clayey tills and lacustrine clays are considered to be aquitards restricting the horizontal or downward movement of water. The hydraulic conductivities of these deposits are likely in the order of 1×10^{-6} to 1×10^{-8} cm/sec, except where they have been enhanced by fracturing or sinkhole activity.

4.3 Sinkhole Development

Sinkholes have developed in the overburden at several areas around the mine, most noticeably along the river. These appear to be of three main types:

- Sinkholes that have developed in sand overburden directly from underground mine intersections
- Sinkholes that have developed in sand overburden from apparent rock cavern (karst) collapse
- Sinkholes that have propagated through till.

The potential occurrence of water-filled or permeable soil filled cavernous zones adjacent to areas of mining presents the potential for rapid water/soil inflow to the underground mine workings and the development of sinkholes to surface. This potential is schematically illustrated on Figure 11. Sinkholes that resulted from the intersection of mine workings with permeable, saturated soils include the 110 Drift sinkhole in 1979 and the 104 Sinkhole which occurred over the 1982 to 1989 mine shutdown period.

The second category is considered to be directly related to collapse of karst caverns in the gypsum bedrock. Taylors Pond to the north of the mine may be typical of a post-glacial sinkhole that has developed in this manner. Its occurrence though, pre-dates any mining activity.

Recent sinkholes that have developed in the Upper Sand strata adjacent to and in the bottom of the Gays River near Borehole GA-9 may reflect cavern collapse of zones within the underlying gypsum bedrock. Several (possibly five) sinkholes have occurred in this area during the 1989-1991 dewatering period. One of these sinkholes developed within the river bottom immediately north of Borehole GA-9. These collapse features vary up to 3 m in depth and are typically 5 to 6 m in diameter. The collapses may have been initiated by lowering of the bedrock water levels such as near Borehole GA-9 where the bedrock water levels are up to 7 m lower than the river level as a result of mine dewatering.

Sinkholes have also propagated to surface through the Red Till unit. Most of the sinkholes upstream of Borehole GA-10 appear to be of this nature where the area is largely underlain by the Red Till unit. The mechanism is considered to be either bedrock cavern collapse or the sapping of underlying sand strata into the mine by the dewatering activity. This latter form of development is illustrated in Figure 12 and could be a possible method of development of the 119 Sinkhole located adjacent to Borehole GA-14.

The evidence for the sapping of material to the underground environment is that fine sand and silt was discharging to underground sumps at significant rates prior to the installation of well screens in the Aardvark drain holes (Golder Associates Report 911-1721, November 1991). Monitoring of the 118 Sump drainholes by the mine in 1991 indicates that the total suspended solids load presently carried in the groundwater discharge averages approximately 0.03 percent by weight thus total amount of material discharged on a daily basis at an average pumping rate of 4500 USGPM, would be about 7.4 tonnes/day. Peak suspended solids discharges are in the order of 0.2 to 0.4 percent representing approximately 49 to 98 tonnes/day of material. However these peak rates occur only occasionally. The loss of fine sand and silt at the average rate over time could potentially develop voids beneath the till causing it to develop upward-propagating failures. Some of the smaller sinkholes developed in the Red Till in the river bed directly north of the DW-1 and OW-2 monitoring well locations appear to be of this nature although there appears to be little indication of vertical leakage associated with them. The major concern would be for the development of a large sinkhole failure in the river bottom directly over the mine that could potentially result in a direct connection between the river and the mine.

5.0 HYDROGEOLOGY

5.1 Hydrostratigraphy and Flow Systems

The overburden deposits can be classified stratigraphically into a series of acquitards and aquifers. As discussed in Section 4.2, the sandy horizons such as the Upper Sand, Lower Sand, Cretaceous Sand and cavern infill zones are quite permeable water bearing aquifers. In contrast, the clayey soils are low permeability units or aquitards. These aquitards include the Upper Lacustrine Clay, the Red Till, the Lower Lacustrine Clay, the Lower Till and the Cretaceous Clay.

5.1.1 Aquitards

The Red Till is the most persistent clayey horizon encountered across the mine site area. Accordingly, it is considered to be the principal aquitard controlling surface water infiltration beneath the various brooks and the Gays River and controlling the rate of groundwater recharge from the Upper Sand to the Lower Sand and the underlying karst gypsum zones that drain to the mine. However, the till does not occur everywhere. It is absent downstream of the mine in the vicinity of Borehole GA-8, 9 and 10 (see Sections AA, DD, EE, Figures 8 and 10). The Red Till is also breached by sinkhole development, notably in the stretch of river extending upstream of Borehole GA-14. Thus, recharge water from rainfall or other sources would have an enhanced seepage pathway downward to the bedrock and trench zone in the areas where the till is absent or breached by sinkholes.

5.1.2 Aquifers

The Upper Sand aquifer is present beneath the mine administration area, through the sand pit, northward to the river and also downstream in the main river valley. It may also extend southward in the valley towards the tailings basin. The sand is dewatered within the sand pit area and northwestward toward Boreholes GA-4 and GA-16. Groundwater is locally perched within the Upper Sand where it is underlain by Red Till adjacent to the river at Boreholes GA-14 and GA-15 (see Section AA Figure 8). Downstream, alongside Boreholes GA-9 and GA-10, the water level in the Upper Sand is some 4 to 7 m below the adjacent river level indicating that the

river is infiltrating to the Upper Sand in response to the downward hydraulic gradients shown by the water levels. The Upper Sand is also potentially in direct contact and hence hydraulic connected to the gypsum bedrock within this area as discussed in Section 4.1.3. The hydraulic connection between the sand and bedrock may have been enhanced by the sinkhole development that has occurred both in the past and recently within this area.

The Lower Sand aquifer was found to extend northward from the mine beneath the Meadow Brook Valley in the area from Borehole GA-13 to GA-18 (see Section EE, Figure 10). A projection of the soil stratigraphy and bedrock surface shown on Figure 10 suggests that the Lower Sand may vary in thickness within a range of 8 to 26 m within this area.

The Lower Sand appears to behave as a semi-confined aquifer beneath the Red Till aquitard based on the water levels for GA-12 and GA-18 shown on Section EE. As of October 1991, the Lower Sand had been depressurized to about the level of the contact between the sand and the overlying Red Till. In fact, by October the Lower Sand water levels were some 10 to 14 m below river level, having shown very little fluctuation over the monitoring period, indicating that they had reached a steady state condition. It is of particular note that the sand had been completely drained in the vicinity of Borehole GA-13 and Well OW-3, directly overlying the mine workings.

A number of the cavernous gypsum karst zones associated with the trench are variously infilled with permeable sands and gravels. Open voids or cavities also occur. As such, they potentially constitute the major water bearing zone adjacent to the mine. Such zones extend westward along strike from the mine, but no extension east of the Taylors Pond area has been identified, based on the extensive mining exploration drilling within that area. The extent of the karst zones within the gypsum to the north of the trench area is not clearly understood as insufficient drillhole data is available.

The gypsum basin southeast (upstream) of the mine and any permeable karst zones associated with it are likely separated from the mine by the northeast-southwest trending outlier of Goldenville quartzite and Gays River carbonate (see Figure 4). Significant hydraulic connection between the mine and the southeast basin would therefore be limited to overburden pathways across the carbonate and quartzite outlier, such as within the Lower Sand.

5.2 Mine Drawdown

The extent of mine related groundwater level drawdown has been defined within the immediate mine site area from the results of the present drilling investigation. The potential zone of mine drawdown, beyond the limits of the drilling investigation, has been estimated in an attempt to define the total groundwater catchment area of the mine.

5.2.1 Mine Site Groundwater Levels

The water levels in the deeper strata such as the Lower Sand and bedrock within the mine site have been significantly depressed due to underground drainage toward the mine. A schematic groundwater level elevation contour plan for the deeper soil strata and bedrock within the mine area is shown on Figure 13. The water levels shown on Figure 13 were measured in the various piezometer/monitoring wells on September 25th, 1991 and are considered to be reasonably representative of typical site conditions. Data from underground pressure monitoring locations (PT-1 to PT-12) were measured on September 26, 1991 and are also included in the interpretation.

The dewatered portions of the mine workings have locally lowered groundwater levels some 70 to 85 m below river level based on the pre-existing deep monitoring wells and underground pressure monitoring locations. The steep zone of drawdown associated with water levels below an elevation of 500 m is almost entirely focused over the mine workings and the trench as indicated by the water level contours on Figure 13. The contours also indicate that the drawdown cone is a relatively narrow, steep-sided, linear feature following the trace of the underground workings, as would be expected. The drawdown cone significantly flattens beyond this area.

The drawdown cone is considered to extend at least beneath those areas where the groundwater levels have been lowered below the river level of 515 m. Accordingly, it appears to extend approximately 1200 to 1500 m north of the mine beneath the Meadow Brook Valley where the Lower Sand aquifer appears to have reached steady state conditions, based on water levels. The projected groundwater levels south of the mine indicate that there is a continual slope in groundwater levels from approximately 520 m near the tailings pond northward to the mine. This

would suggest that the drawdown cone reaches the tailings pond. However, connection between the tailings pond and the mine would be largely limited to seepage through the Upper Sand due to the relatively low permeability of the underlying Goldenville Formation. Underground mining and the sand pit excavation experience has indicated that relatively little mine water appears to originate from the tailings pond area to the south based on the minor amounts of seepage that occur in the footwall zone. Also, it is not known whether or not the Upper Sand actually extends beneath the tailings pond in this area. A further indication that little seepage originates from the tailings pond was obtained during the extremely dry summer of 1991, when the inflow and outflow from the tailings pond was essentially in balance while the pond was maintained at a relatively stable level.

Further, although the drawdown cone extends eastward to the mine site entrance area (GA-1) it does not appear to extend into Black Brook, based on groundwater levels in Borehole GA-19. Therefore, the Black Brook area does not appear to be within the zone of influence of the mine dewatering and may not contribute significantly to total seepage, based on the presently available water level information. The cone does however extend westward to Borehole GA-8 on the South Branch Gays River where the water level in the underlying gypsum is 1 m to 2 m below river level. This area is also associated with minor, recent sinkhole development within the river bed. Therefore, based on these observations, the South Branch Gays River likely contributes an appreciable measure to the mine seepage in the area where it overlies the trench zone and potentially downstream to the confluence.

5.2.2 Potential Zone of Mine Drawdown

The potential zone of mine-related groundwater level drawdown and hence the groundwater catchment zone of the mine cannot be precisely defined due to the limited number of wells located outside of the immediate mine area. However, the area of potential drawdown can be extrapolated beyond that shown by the groundwater elevation contours on Figure 13 by taking into consideration the bedrock structure, overburden stratigraphy and local topographic drainage divides. Accordingly, an approximation of the potential zone of influence of groundwater level drawdown related to the mine is shown on Figure 14. The total zone is estimated to be approximately 10 km^2.

In developing this drawing, it has been assumed that the zone of drawdown will not extend southward from the mine much beyond the area underlain by the resistant, low permeability outlier of the Goldenville and Gays River Formations, which separate the mine area from the tailings pond and also the evaporite basin to the south (as previously discussed in Section 5.1). The zone of drawdown potentially extends west of the South Branch Gays River following the western extension of the trench, as indicated by the slightly depressed water levels in Boreholes GA-8. The overburden stratigraphy suggests that the Lower Sand aquifer could extend for a considerable distance northward of Borehole GA-18 and could also potentially underlie most of the Meadow Brook Valley. Therefore, considering that the Lower Sand apparently behaves as a semi-confined aquifer draining to the mine, the zone of mine drawdown could potentially extend throughout much of the Meadow Brook Valley basin. However, the drawdown does not apparently extend beneath the Black Brook basin, based on the available monitoring well information.

Further, based on the available data, it has been assumed in developing Figure 14, that the slope of the water table and hence the direction of groundwater flow will reverse beneath the prominent ridges that form the topographic divides to the west of the mine and rim the Meadow Brook basin (see Figure 14), considering that groundwater levels normally tend to conform somewhat to surface topography. Therefore, these divides are considered to likely represent the maximum extent of mine drawdown influence.

5.3 Groundwater Recharge

The source of groundwater that enters the mine is a combination of recharge from precipitation within the total zone of groundwater level drawdown and recharge from the overlying river. The infiltration from precipitation within the zone of drawdown can be estimated from climatic conditions, while the influence of the river was directly investigated through the diversion of the mine discharge to the South Branch Gays River between July 25 and September 15, 1991. These two aspects are discussed in the following sections.

5.3.1 Recharge from Precipitation

The area over which precipitation will infiltrate into the ground as groundwater recharge, and ultimately report to the mine as underground drainage, is approximated by the total zone of groundwater level drawdown toward the mine. Based on the previous discussion in Section 5.2, the total zone of drawdown toward the mine and hence the potential maximum extent of groundwater recharge from precipitation, may be in the order of 10 km^2 (see Figure 14).

The amount of infiltration from precipitation that is potentially available for groundwater recharge within areas largely underlain by overburden such as in the vicinity of the mine, is generally within the range of 15 to 30 percent of the total annual precipitation (1400 mm). This would be approximately 210,000 to 420,000 $m^3/km^2/yr$. (The actual rates of infiltration will vary dependent upon such factors as soil type, runoff characteristics and vegetation). However, based on these estimates, the total amount of precipitation-related recharge that could potentially report to the mine would be in the order of 2.1 to 4.2 million m^3/yr within the approximated 10 km^2 area of drawdown. When averaged over a period of 1 year, this amount of recharge water would be equivalent to approximately 1,055 to 2,110 USGPM.

These estimates are considered very approximate due to the uncertainties in the actual extent of mine-related drawdown and actual infiltration. However, the estimates do serve to provide an indication of the potential scale of mine inflow that could be experienced simply due to precipitation-related recharge. A more precise indication of the infiltration can be made by separating out the baseflow component of the river hydrograph over an annual period. The baseflow represents the net effect of infiltration. Therefore, infiltration will approximately equal the percentage of the annual precipitation represented by the baseflow.

Typically, most of the recharge occurs during specific months of the year such as during the spring runoff and fall rains when the influence of evapotranspiration is reduced. However, in this case, due to the large size of the potential recharge area and also the associated seepage distance to the point of discharge (the mine), the recharge value determined will tend to provide an averaged groundwater flow throughout the year that will tend to show only minor fluctuations with seasonal change.

5.3.2 Recharge from the River

The Gays River is within the zone of influence of the mine drawdown cone for a distance of about 2.5 km, extending from about the Black Brook confluence downstream to the confluence of the north and south branches of the river. The river is considered to be the only significant source of surface water infiltration within this area, other than that provided by precipitation and associated infiltration along the trench zone. The tailings pond is not considered to be a significant source of infiltration due to the underlying geology and seepage observations noted during mining, as discussed in Section 5.2.

Surface water from the river will recharge downward in response to the downward hydraulic gradients induced by mine dewatering, and it will drain through the overburden or a combination of overburden and bedrock pathways towards the mine. The rate of infiltration will depend on the nature of the overburden strata underlying the river. For example, in those areas underlain by the Red Till aquitard, little downward recharge would be expected to pass through the till, except in those areas where it is thin and/or fractured or breached by sinkholes. Conversely, significant amounts of downward recharge would be anticipated where there is no aquitard, (ie. where sand overlies permeable bedrock that is in hydraulic connection with the mine) such as is anticipated in the area northwest of the 118 Sump.

In order to establish the influence that the river might extert on mine inflows, an experiment was carried out by the mine involving the diversion of the mine water discharge from the north branch to the south branch of the river over the period between July 25 and September 15, 1991. The summer of 1991 (including July and most of August), was an extremely dry period with very little rainfall. During this period, the mine discharge water was providing the bulk of the flow in the main branch of the river. The result of the diversion was the drying up of a section of the main branch of the river passing the mine.

An analysis of the effects of the results of the diversion and precipitation events on river flow, mine pumping rates, river level fluctuations and groundwater level fluctuations has led to a direct estimate of river infiltration to the mine. A summary of the effects of the mine discharge diversion and precipitation events on river flow, on river levels at the mine bridge, on mine

pumping rates and on groundwater levels is provided on Figure 15.

5.3.2.1 Mine Discharge Diversion Influence on River Flow

The average pumping rate for the period prior to the diversion was approximately 4,000 USGPM (see lower diagram on Figure 15). At that time, the flow in the river upstream of the tailings basin confluence was visually estimated at about 500 to 1,000 USGPM. Therefore, the total river flow passing the mine was approximately 4,500 to 5,000 USGPM. These flow rates were unfortunately below the accuracy of the stream gauge established at the mine bridge, which cannot reliably measure flows below 10,000 USGPM due to the limitations of it calibration curve. Therefore, accurately measured flow rates during the diversion are not available.

The diversion of the mine discharge water was carried out between July 23 and July 25, 1991. The diversion was approximately 50 percent complete by the end of July 24 and entirely completed on July 25. The complete diversion of the mine discharge water on July 25 resulted in a progressive decrease in the flow of the main branch passing the mine. By July 27, the north branch of the river ceased to flow to the confluence with the south branch and the drying of the river bed began to progressively retreat upstream. For the period between August 1 and 6, the entire river channel drained dry downstream of the sinkhole (the swimming hole) located alongside Borehole GA-10. Some water remained ponded in other sinkhole depressions within this area but most of the river bed could be walked upon. The amount of water reaching the sinkhole at Borehole GA-10 was estimated to be approximately 100 to 200 USGPM and this water flow then infiltrated through the sinkhole bottom. Most of the remainder of the river flow (of 500 to 1,000 USGPM) was therefore infiltrating into the river bed upstream of the swimming hole sinkhole. Subsequently, on August 1, the mine increased the flow in the river by adding up to 200 USGPM of mine discharge water to maintain flow in the river to the sinkhole (swimming hole) for recreation purposes.

Nevertheless, river flows did not reach the south branch confluence until between August 13 and 14 when rains caused the flow to return (see Figure 15). The flow again ceased between August 15 and 19 after which time heavy rainfall on August 19 returned the flow to the river. River flow then continue to the end of the diversion period except for the brief period of September 6

and 7 when the river course again went dry.

The diversion clearly indicated that river water infiltrated the overburden deposits beneath the river at a rate of at least 500 to 1,000 USGPM. Considering that the infiltration occurred within the groundwater drawdown cone of the mine, this infiltration, or river recharge would have flowed to the mine.

5.3.2.2 Mine Pumping Response

The changes in mine pumping rates during July, August and September 1991, including the diversion period between July 25 and September 15, are shown on Figure 15. The various pumping rate fluctuations occurring prior to, during and following the diversion appear to result directly from influences such as the diversion itself, variation in rates of underground drainage, rainfall events and river flooding. An appreciation of the pumping fluctuations is considered essential when attempting to assess the significance of river recharge to the mine. The mine pumping rates were calculated daily by the mine from the separate discharge of both the 118 sump and the 825 sump areas. A continuous water level recorder chart set at a weir monitors the combined central mine pumping discharge from the 118 sump area and a flow meter monitors on the separate 825 Sump discharge line. The combined values, reported in USGPM, represent the average pumping rate or mine discharge between 8:30 AM of the preceeding day to 8:30 AM on the reported day. As such, the discharge rates shown on Figure 15 are more representative of the end of the preceeding day.

It should be noted that prior to July 20 1991, the flow meter had not been installed on the 825 sump discharge line and the flows from the sump prior to the meter installation were based upon the rated pump capacity for the given head. However following the meter's installation, the mine recognized that the discharge for the previous period was underestimated by approximately 100 USGPM. Therefore, the reported total pumping rates shown on Figure 15 for the period prior to July 21 are underestimated by about 100 USGPM.

The reported average daily pumping rate between July 1 and 7, 1991 fluctuated between approximately 3,800 and 4,100 USGPM, averaging 3,945 USGPM, (or 4,045 USGPM when

corrected for the underestimation), remaining relatively constant until a series of underground drainhole blockages occurred in the 118 Sump between July 7 and 9. The blockages resulted in a relatively sudden drop in the pumping rate to approximately 3200 USGPM between July 10 and 12 which was also associated with relatively rapid rises in water levels in the nearby monitoring well DW-3 as indicated on the top diagram on Figure 15. The clearing of the drainhole blockages resulted in an increase in the pumping rate to approximately 3,800 to 3,900 USGPM between July 14 and 17 which approximately coincides with the initial decline in water levels in nearby well DW-3.

Maximum pumping rates for July occurred between July 18 and 28, including the 7 days prior to the diversion and continuing for the initial 4 days of the diversion period. The pumping rates over this eleven day period varied between approximately 4,000 and 4,460 USGPM, averaging approximately 4,150 USGPM. Underground drainhole development was ongoing during this period and may account for some of the discharge fluctuations. Notably, the clearing of 118 Drainhole No. 1 directly resulted in the 1 day increase to 4,460 USGPM shown on Figure 15.

Following the fourth day of the diversion, the pumping rate began to steadily decline. (Some fluctuations in the pumping rate during the decline could be associated with precipitation events such as the 34.8 mm of rain that fell on July 27). The lowest pumping rates experienced during the diversion occurred between August 8 and 14 when the rates ranged between 3,190 and 3,391 USGPM, averaging approximately 3,350 USGPM (see lower diagram on Figure 15). The difference between the average pumping rates for the week preceding the diversion and the period of lowest average pumping rate during the diversion was approximately 800 USGPM.

When considering the pumping rate for the entire previous month as well as the preceding week, the relative decline in pumping is in the range of 500 to 800 USGPM. This drop in the inflow to the mine is considered to be primarily a result of the drying up of the river bed downstream of the swimming hole by Borehole GA-10. As a result, this section of the river could no longer contribute water to the mine.

The pumping rate increased following August 14 reaching 4,000 USGPM on August 23 and continued to increase to 4,555 USGPM by the end of the diversion (Sept. 15), as indicated on

the lower diagram on Figure 15. The increase appears to have occurred as a result of rainfall and rising river levels. Following the diversion, the pumping rates remained relatively constant, fluctuating between approximately 4,300 to 4,750 USGPM through to September 20. Between September 21 and 30, the pumping rate then rapidly rose from approximately 4,800 to 6,100 USGPM in direct response to heavy rainfall and the inundation of the river flood plain (see Figure 15).

5.3.2.3 Precipitation

Daily precipitation data for the mine area is based on records from the Halifax airport, as shown on Figure 15. In July 1991, the mine area received very little rainfall preceding the diversion, but a significant rainfall of 34.8 mm occurred on July 27 and additional rainfall occurred on August 5 (16.3 mm) (see Figure 15). These events had very little influence on the river level and the rain was likely consumed by the dry vegetation and resaturation of the soil above the water table.

Rainfall on August 11 (26.7 mm), resulted in a noticeable rise in the river level and a comparatively large rainfall on August 19 (53.4 mm) followed by a lesser event on August 24 (17.4 mm) was associated with a 0.65 m increase in river levels and the return of flow to the river confluence as indicated on Figure 15. This was then followed by a relatively dry period through to September 6th, after which more rainfall events occurred. Another large rainfall event occurred over two days between September 19th (20.0 mm) and September 20th (50.6 mm), following the end of the mine discharge diversion period, which resulted in the inundation of a large portion of the river flood plain.

In summary, the total rainfall for July was 61.4 mm while August received approximately double that amount at 128.1 mm and September received 147.2 mm. The total amount of rainfall over the monitoring period shown on Figure 15 was 536.7 mm.

The amount of precipitation received in each month can be compared with the total monthly runoff for the basin upstream of the mine gauge, an area of approximately 94 km^2, to obtain an indication of what percentage of the rainfall for the period actually entering the active flow

system, (assuming for this situation, that the rainfall measured at the airport also occurred uniformly over the entire drainage basin). Making this assumption for July and August 1991, for example, the river discharge is calculated to respectively account for approximately 14 and 19, percent of the total volume of rainfall received, indicating that a very large portion of the rainfall for this period was lost as evapotranspiration. These conditions are representative of an extremely dry seasonal period. Due to the dryness, a portion of this late July and August rainfall would also be expected to be retained as soil moisture in the unsaturated zone of the drainage basins.

Between September 1 and 19, the amount of runoff increased to approximately 25 percent of the total rainfall that fell in the period. By contrast, the comparatively heavy rains in the latter half of September apparently completely saturated the basin such that runoff between September 19 and 30 is calculated to represent approximately 82 percent of the total rainfall received for that period. This latter period coincides with the sharp increase in river level and the inundation of the river flood plain shown on Figure 15.

5.3.2.4 River Level Fluctuations

Daily river level monitoring, which is carried out at the mine bridge, provides an indication of the upstream river responses during the diversion period.

The river level was quite constant during the week prior to the diversion on July 25, only varying in elevation between 515.20 to 515.22 m. The level dropped approximately 0.15 m to 515.05 m on July 26, the day following the diversion, and remained within a relatively constant elevation of 515.04 to 515.09 through to August 6. The river flow associated with these river levels was visually estimated to be in the order of 500 to 1,000 USGPM. During the period when river levels at the bridge fell below an elevation of approximately 515.15 m, the river ceased to flow to the south branch confluence. Complete drying of the river bed occurred when the level fell further to somewhere between 515.04 and 515.07 m.

On August 7 and 8 respectively, the river rose slightly to 515.15 and 515.13 m, probably in response to the August 5 rainfall events. It then fell to the previously low range until August 11

when it returned to 515.13 m, reaching maximum levels of 515.29 m, apparently in response to the 26.7 mm rainfall event on August 11. Following the passage of the rainfall event, it again declined until August 19th when it rose relatively sharply from 515.06 m to 515.43 m on August 20 following 53.4 mm of rain. During this runoff event, the river reached a maximum elevation of 515.70 m then declined (see Figure 15).

When the mine discharge was returned to the river following the end of the diversion period, no significant change in the river level was noted. Immediately prior to the diversion (ie. between September 12 and 15), the levels varied from 515.31 to 515.34 m, while following the diversion, they remained within the same range until heavy rainfall events occurred on September 19 and 20. During the interval between September 16 and 18, levels were some 0.10 to 0.15 m above the pre-diversion levels and correspondingly, the mine pumping rates were higher (see Figure 15). However, the levels in the river rose rapidly in response to the September 19 and 20 rainfall events and then stayed within a range of 515.81 to 516.22 m between September 21 and 30 when levels rose above 515.75 m, (the level where the river flood plain starts to become inundated). River flow rates increased dramatically during this period, varying within a range of 84,500 to 203,400 USGPM. This period of higher river levels and associated greater flows coincided with the sharp increase in mine pumping rates to 6,100 USGPM in late September 1991.

5.3.2.5 Groundwater Level Fluctuations

The mine discharge diversion period and the associated fluctuations in river level in response to the rainfall events in August and late September, are also mirrored by groundwater level fluctuations in several overburden and upper bedrock piezometers, including monitoring well DW-3 located within the central 118 Sump area. The water levels in Well DW-3 in fact, show clear responses to individual events. The levels responded rapidly to drainage hole blockages in early July and also sharply reflected other events such as the one day increase in underground drainage associated with a 9 m water level drop in DW3 that occurred between July 24 and 25 immediately prior to the complete diversion as shown on Figure 15. The levels in DW-3 also later rose sharply in response to the late August and early September rains and the associated changes in river level. The increased flow and sharp rise in river level following September 20,

1991 was also reflected in a comparatively rapid rise in the DW-3 water levels from approximately 438 up to 449 m (see Figure 15). This period corresponds to the inundation of the flood plain following heavy rainfall.

The response of DW-3 is of some interest in that it rapidly responds to changes in underground or surface flows. It is suspected, therefore, that its behaviour is dominated by some major permeable zone that intersects the hole. Specifically the fact that the lower water level bound of 438 to 439 m occurs, suggests that some form of "boundary condition" may exist within the well at this elevation. This is confirmed by the fact that the well is completed in the footwall bedrock which at the 438 to 439 m elevation coincides with a major gamma spike at a depth of approximately 90 m in the well as shown on the borehole record in Appendix B. This level may therefore reflect a major permeable fracture below which the well is not permeable and hence, the well does not respond when mine water levels are drawn down below the 438 to 439 m level, whereas above this level the well responds comparatively rapidly.

Groundwater level responses were also noted over the diversion period in the mine observation well ETW-2 (see Figure D-37 of Appendix D). The level in the well was about 451.5 m prior to the diversion and it fell to about 444.7 m by August 7 then rose to about 452 to 453 m during the remainder of the diversion period.

Within the outlying areas away from the main centre of drawdown, the most notable water level trends were associated with five piezometers (GA-6-1, GA-9A-1, GA-10A-1, GA-22A-1 and GA-27-1) as summarized on Figure 15. These piezometers are all located in the area to the northwest of the 118 Sump as shown by the circled locations on Figure 13. They monitor the area between the 118 Sump and the portion of the river that went dry downstream of the sinkhole alongside Borehole GA-10. They also monitor the area adjacent to the section of the river where the Upper Sand aquifer may be in direct contact with the bedrock.

Although the piezometers were not in place at the start of the diversion experiment, water levels were able to be recorded in GA-9A-1 (gypsum bedrock) and in GA-10A-1 (gypsum bedrock and Cretaceous Sand layers) on a semi-daily basis following July 31, 1991. The groundwater levels in these piezometers dropped 1.7 and 1.2 m between July 31 and August 7th during the period

when the adjacent portion of the river went dry (see Figure 15).

The water levels in the piezometers in these same boreholes began to rise on August 14 following rainfall events and associated increases in river flow, and they continued to rise until August 30. The groundwater levels then remained at relatively constant elevations around 506 to 507 m until about September 23, when they again began to rise, probably in response to the late September rainfall and rising river levels. This period of rising groundwater levels was also associated with relatively sharp increases in pumping rates shown on Figure 15.

5.3.2.6 Potential River Recharge

The various observations obtained during the diversion experiment have confirmed that the north branch of the river does contribute recharge water to the mine based on the drying up of the river. The rate of recharge is at least in the order of 500 to 1,000 USGPM based on the upstream flow estimates for the river. Most of the observed flow appears to have recharged along the river course upstream of Sinkhole 5 (the swimming hole) as previously discussed.

The infiltration of surface water from the river to the mine is therefore likely induced by the relatively constant downward hydraulic gradient that exists in the overburden and underlying bedrock as a result of the mine being maintained in a dewatered condition. As the river was at a period of very low flow (500 to 1,000 USGPM) and confined to its channel at the time when it ceased to flow during the diversion, the recharge estimate of 500 to 1,000 USGPM, based on the upstream flow, is a minimum value of the capacity of the section of the river upstream of Borehole GA-10 to recharge the underlying groundwater system.

Prior to the diversion, when the river was flowing through the site at several thousand USGPM, the river would have been contributing the minimum infiltration of 500 to 1,000 USGPM plus some additional water from the river section that went dry downstream of the sinkhole by Borehole GA-10. An estimate of how much additional water that may have been entering the groundwater system could possibly be represented by the decrease in the pumping rate associated with the diversion of the mine discharge from the river.

Based on the preceding discussions of pumping rates, it is difficult to quantify the actual decrease in the pumping rate as a result of the diversion simply because of the ongoing underground drainage development work. However, the pump rate monitoring data does suggest that the mine discharge rate was within an average range of about 3,850 to 4,150 USGPM. Therefore the reduction in the pumping rate to the lowest average rate of approximately 3,350 USGPM would suggest a flow contribution range of 500 to 800 USGPM. If this were the case, then the total river recharge may have been in the order of 1,000 to 1,800 USGPM during early July 1991. As the river at that time was flowing at a very low rate, confined within its channel, the estimated recharge rates are considered to represent the minimum recharge rate from the river.

The decline in the measured average pumping rates ceased following the third moderate rainfall event that occurred on August 11, 1991. This also resulted in the return of river flow past the mine. The two preceding rainfall events (July 27, August 5) would have begun to resaturate the ground within the river drainage basin following the extremely dry period, resulting in a slow increase in the baseflow discharge and hence the river flow past the mine. The large rainfall on August 19th apparently completed the resaturation and also returned the river flow to the downstream confluence. This also increased the available area for river infiltration. This, coupled with regional groundwater infiltration from direct precipitation, effectively returned the pump rates to within the range of 4,000 to 4,500 USGPM. However, had the rains not occurred and increased infiltration to the drawdown cone area and returned the flow to the river bed, it is considered that pumping rates would have continued to decline further as suggested by the downward trend of the pump rate graph shown on Figure 15. Such a continued decrease would therefore have been the result of a two-fold effect including both reduced river infiltration and declining regional groundwater flow in the absence of rainfall infiltration.

The rainfall events in late September that resulted in the inundation of the flood plain confirm this type of hypothesis in that they were immediately reflected by an increase in pumping rates to approximately 5,000 to 6,100 USGPM. This 500 to 1,500 USGPM increase most likely reflects the additional contribution to recharge resulting from the inundation of the flood plain by the river. A portion of this increase would also result from direct rainfall infiltration through exposed sand horizons overlying the mine.

- **Water Balance**

A summary of possible groundwater recharge sources contributing to the mine discharge when the mine pumping rates are averaging 4,000 and 6,000 USGPM is provided on Table 3.

The recharge sources are considered to be infiltration from precipitation or river recharge. The range of precipitation infiltration rates represent annualized estimates appropriate for comparison with order of magnitude pumping rates. River recharge rates are based on the preceding discussion. The category of "balance" presented on Table 3 likely represents uncertainties in the results of the precipitation infiltration rates based on the estimated area of the mine drawdown cone and on uncertainties with regard to the total inflow contribution from the river. No direct balance between the potential sources is indicated by the range of figures used, however, it would appear that river recharge could potentially account for 25 to 50 percent of the mine discharge.

5.3.2.7 Groundwater Flow Pathways

The results of the diversion experiment have conclusively indicated that river water does infiltrate to the mine. The various observations from the experiment and the results of the overburden drilling investigation have indicated several possible groundwater pathways.

A reduction in river flow was observed between the mine bridge and the Sinkhole alongside Borehole GA-10, located approximately 2 km downstream. As the surface overburden drilling has indicated that much of this area is underlain by the Upper Sand and the Red Till aquitard, it is unlikely that the low permeability Red Till would be capable of transmitting the significant amounts of downward infiltration from the river and Upper Sand to allow for the observed decrease in river flow. An exception to this could exist if flow occurs through those areas where the till is thin and/or fractured or breached by sinkholes as previously discussed. The fact that some sinkholes have been identified within this area, notably in the Sinkhole 119 area by Borehole GA-14, suggests that pathways most likely occur as a result of the breaching of the Red Till. The cluster of sinkholes noted to have progressively developed in the Sinkhole 119 area since dewatering activity began in 1989 again suggests an active hydraulic connection with the mine.

There is also the possibility that complex downward flow pathways exist within the Upper Sand whereby the Red Till is circumvented. It was noted that saturated Upper Sand overlying Red Till was encountered adjacent to the river in Boreholes GA-14, GA-15, and P-6, (see Section A-A, Figure 8) while to the south, directly above the mine, the Upper Sand, although unsaturated, was in direct contact with the bedrock at depth (at Boreholes GA-4, GA-16). This is considered to imply that some direct Upper Sand related seepage pathway may exist between the mine and the river within this area.

The drying of the river to the northwest of the 118 Sump and downstream of Sinkhole 5, and the associated fluctuations in groundwater levels is also considered to imply the existence of significant groundwater flow pathways from the river to the mine beneath this area. The high probability of a direct connection between the Upper Sand, which forms the river bed within the area of Sinkhole 5 and downstream to the confluence, and the permeable gypsum bedrock has been previously discussed. This would provide a direct seepage pathway from the river to the permeable gypsum, such as encountered in Borehole GA-9, and hence via gypsum fracture/solution pathways to the mine. Further, the hydraulic connection between the river, the Upper Sand and the gypsum has likely been enhanced by the sinkhole activity that has occurred in this area.

The suggested potential seepage pathway beneath Sinkhole 5 is less apparent. The Upper Sand at this location appears to be underlain by a relatively thick sequence of Cretaceous Clay, based on the adjacent Borehole GA-10. However Cretaceous Sand horizons encountered in GA-10 may correlate with similar sands in Borehole GA-27 (see Section AA, Figure 8). The fact that water levels within the Cretaceous Sand at GA-27 fluctuated identically with the gypsum bedrock and Cretaceous Sand horizons in GA-10 during and following the diversion (see Figure 15), suggests a potential hydraulic connection between the river and the mine via pathways within the Cretaceous Sand. This would probably require the Cretaceous Sand to be in direct contact with the Upper Sand, such as could occur in a sinkhole collapse area.

Another postulated seepage pathway occurs in the vicinity of the western end of the mine where the Lower Sand strata underlies the flood plain adjacent to the confluence of the north and south branches of the river (see Section BB, Figure 9). This potential pathway would extend beneath

the area adjacent to Borehole GA-17 where Lower Sand was encountered. It does not occur further northward beneath the Borehole GA-7 area where Red Till lies directly on the gypsum bedrock. Other pathways likely occur; however, due to insufficient information it is not considered possible to be definitive on their locations.

The last major identifiable seepage pathways are the sinkholes and other recharge zones in the river flood plain area. Inundation of the flood plain greatly increases the area for direct recharge to the Upper Sand and accordingly the potential for significantly increased downward infiltration to the mine. Such inunduations would also increase the potential number of sinkhole features in direct contact with the river. This latter effect appears very significant, based on the sharp increases in mine pumping rates experienced during periods of flood plain inundation.

6.0 CONCLUSIONS

The results of the overburden drilling and evaluation of stratigraphy, hydrogeology and the Mine's dewatering experience allow the following general conclusions to be drawn:

- It has been demonstrated that the mine can be maintained in a dewatered condition to elevations of approximately 400 m to 410 m with pumping rates in the range of 4,000 to 6,000 USGPM, depending upon seasonal variations in precipitation.

- The overburden stratigraphy is complex and eight major soil units have been identified. These units consist of outwash sands and gravels, lacustrine clay and clayey till and Cretaceous clay and sand deposits that can be correlated across the site.

- The principal water bearing overburden units are the Upper Sand, Lower Sand and Cretaceous Sand. These sands are permeable and are considered capable of transmitting significant quantities of water. The zones of sand infilled cavities within the karst gypsum are also considered to be significant water-bearing horizons.

- The clayey soils, including the lacustrine deposits and tills, are aquitards that restrict the lateral and vertical movement of water. The Red Till is considered to be the most extensive and significant soil aquitard.

- Zones of open, interconnected karst voids within the evaporites, notably near the bedrock surface and adjacent to the trench area, appear to constitute a major bedrock aquifer.

- The quartzite and carbonate bedrock is generally of low permeability and will likely restrict the movement of groundwater between the evaporite basins to the north and south of the mine.

- Overburden sinkholes have developed at several locations within the river channel and flood plain to the north of the mine. These features breach the Red Till aquitard and likely contribute infiltration, especially during periods when the river inundates the flood plain.

- Overburden sinkhole development associated with the mine is likely initiated by underground drainage to the mine through lowering of groundwater levels and sapping of silt and sand material through the underground drainage holes. The latter can be remediated to some degree through the use of well screens in the drainage holes, which has been undertaken. Prevention of the sapping of fine grained soils underground is considered very important to prevent further sinkhole development. Sinkholes can also occur naturally through solution weathering of the evaporites and seasonal water level fluctuations.

- The Upper Sand unit is probably in direct hydraulic communication with permeable gypsum beneath the Gays River some 600 m to the northwest of the 118 Sump. Direct infiltration to the Upper Sand, and thence potentially to the mine, apparently occurs in this area as observed by the drying of the river following the mine discharge diversion in July 1991. The hydraulic communication is likely enhanced through local sinkhole development.

- Groundwater pathways also occur from the river to the mine beneath the area to the north of the 118 Sump, based on the decrease in river flow noted within this area during the mine discharge diversion. The pathways may be associated with seepage within the Upper Sand passing downward through sinkholes that breach the underlying Red Till such as the 119 Sinkhole area.

- The principal delivery path of groundwater to the mine is considered to be interconnected karst zones in the gypsum adjacent to the trench. This includes both sand and gravel filled cavities and cavernous voids. Groundwater will migrate laterally along strike within the trench as well as southward within the upper weathered surface of the evaporites from the area north of the trench. These zones will collect the water seeping downward from the overburden and deliver it to the mine.

- The groundwater drawdown cone is steep and comparatively narrow within the immediate mine workings area and the trench zone. This may be partly responsible for the rapid rise in water levels observed when drainhole blockages or rapid recharge events occur.

- The total potential zone of influence of the groundwater drawdown cone associated with the mine is estimated to be 10 km^2.

- A comparison of the potential zone of influence of the drawdown cone and potential infiltration from precipitation suggests that direct precipitation may account for approximately 1,055 to 2,110 USGPM on an annual basis assuming infiltration rates of 15 to 30 percent. The flow rates would likely vary with the actual infiltration events.

- Surface water infiltration from the river to the mine is induced by the vertical hydraulic gradients created by the dewatered condition of the mine. These gradients correspondingly remain relatively constant. Therefore, infiltration from continuous sources such as the main channel of the river should remain relatively constant varying only with variations in river levels.

- Recharge from the main channel of the river was estimated to be in the range of 1,000 to 1,800 USGPM during the period of low river flow. Infiltration from the river will increase and could double as the river seasonally moves out over its flood plain and greatly increases the potential area of infiltration. It appears that the river could potentially contribute 25 to 50 percent of the total mine drainage.

- The tailings pond does not appear to contribute significant quantities of water to the mine based on pond water balances and mining experience within the footwall zone situated downgradient from the pond.

- Regional transmission of large volumes of groundwater from the east along the karst margin of the trench zone does not appear to be a major factor based upon the present understanding of the mine drawdown cone. The influence may be more significant from the western extension of the trench.

- Mine pumping rates should remain in the existing range of 4,000 to 6,000 USGPM unless sinkhole development increases the amount of river infiltration. Therefore control of sinkhole development is considered fundamental to the predictability of mine dewatering and its consequences on mining activities.

RECOMMENDATIONS

- Continue development of properly screened underground drainage holes to increase dewatering capacity and reduce inflow of silt and sand.

- Obtain a better understanding of the potential zone of mine influence along strike of the trench zone through a review of exploration drilling records to determine areas of karstic cavern occurrence and trench development. Consider instrumenting potential areas along strike with monitoring wells.

- Re-assess the present groundwater level monitoring network in the vicinity of the mine workings and install wells where reliable observations are required.

- Consider establishing a transducer monitoring system for monitoring wells and underground monitoring locations, capable of supplying a central engineering station with continuous water level data. Transducer gauging of the discharge weirs would also supply continuous, automated mine water discharge rates.

- Reassess water quality relationships between the river and mine water at a time when the river flow is not dominated by the mine discharge. This information would assist in assessing hydraulic connection between the river and the mine.

- Evaluate possible engineered modifications to the Gays River channel to reduce infiltration such as:

    - improved channelization
    - channel lining
    - levee construction
    - upstream flow regulation dam

- Evaluate potential for bedrock dewatering wells adjacent to the river in the areas to the north and northwest of the 118 Sump area to intercept groundwater infiltration and decrease flow to the mine. This could potentially reduce the sensitivity of mine water levels to drainage hole blockages.

- Locate and backfill river channel and flood plain sinkholes with clay such as the Red Till to reduce infiltration. Monitor for and backfill any future sinkhole developments.

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TABLE 1

SUMMARY OF SOIL STRATIGRAPHY
GAYS RIVER MINE

AGE	THICKNESS (m)
Recent	
Peat, Clay and Sand Alluvium and Colluvium	1-4
Pleistocene	
Upper Lacustrine Clay	2-7
Upper Sand	2-40
Red Till	3-28
Lower Lacustrine Clay	4-13
Lower Sand	2-26
Lower Till	10-19
Cretaceous	
Clay	2-23
Sand	1-9

NOTE: The trench area and some cavernous zones are variously infilled with less distinct Pleistocene or earlier aged sand and gravel. The nature of these cavern infill deposits is complex and no specific stratigraphic horizon has been assigned to them.

TABLE 2

SUMMARY OF BOREHOLES STRATIGRAPHIC INTERSECTIONS
GAYS RIVER MINE

Borehole No.	Fill	Peat	Alluvium	Colluvium	Upper Lacustrine Clay	Upper Sand	Red Till	Lower Lacustrine Clay	Lower Sand	Lower Till	Cretaceous Clay	Cretaceous Sand	BEDROCK		
													Cavernous Gypsum	Gypsum	Carbonate
GA-1A	✓						✓		✓					✓	
GA-1B	✓						✓								
GA-2				✓	✓		✓								
GA-3	✓				✓	✓									
GA-4	✓					✓								✓	✓
GA-5						?					?				✓
GA-6							✓	✓	✓					✓	
GA-7							✓							✓	
GA-8A			✓											✓	
GA-8B			✓												
GA-9A						✓					✓			✓	
GA-9B						✓					✓				
GA-10A						✓					✓	✓		✓	
GA-10B						✓	✓							✓	
GA-11					✓	✓									
GA-12	✓	✓			✓	✓	✓	✓	✓						
GA-13	✓		✓			✓	✓		✓				✓	✓	✓
GA-14A							✓		✓						
GA-14B			✓			✓	✓								
GA-15					✓	✓	✓				✓	✓			✓
GA-16						✓									
GA-17							✓		✓	✓			✓		✓
GA-18							✓		✓					✓	✓
GA-19			✓		✓		✓								
GA-20						✓	✓								✓
GA-21		✓				✓	✓				✓			✓	
GA-22A						✓									
GA-22B						✓									
GA-23						?	?								✓
GA-24							✓								✓
GA-25					?		?								
GA-26			✓			?	✓								
GA-27						✓	✓	✓	✓		✓	✓			
GA-28A						✓	✓							✓	
GA-28B						✓	✓								

TABLE 3

POTENTIAL SOURCES OF GROUNDWATER RECHARGE TO THE MINE

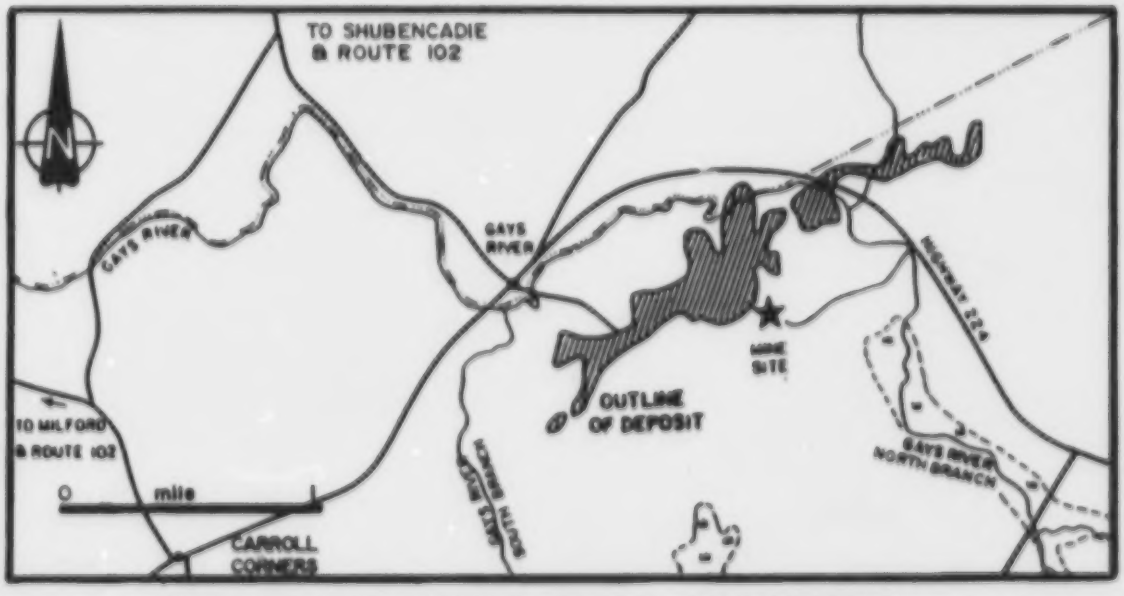
	USGPM	
	Average rate	High Rate
Mine Discharge	4000	6000
Infiltration from Precipitation (average annual rate)	1055 - 2110	1055 - 2110
River Recharge	1000 - 1800	1500 - 3300
Balance	90 - 1945	590 - 3445

SITE LOCATION PLAN

FIGURE 1



GENERAL LOCATION PLAN



MINE SITE AREA SHOWING GENERAL ARRANGEMENT

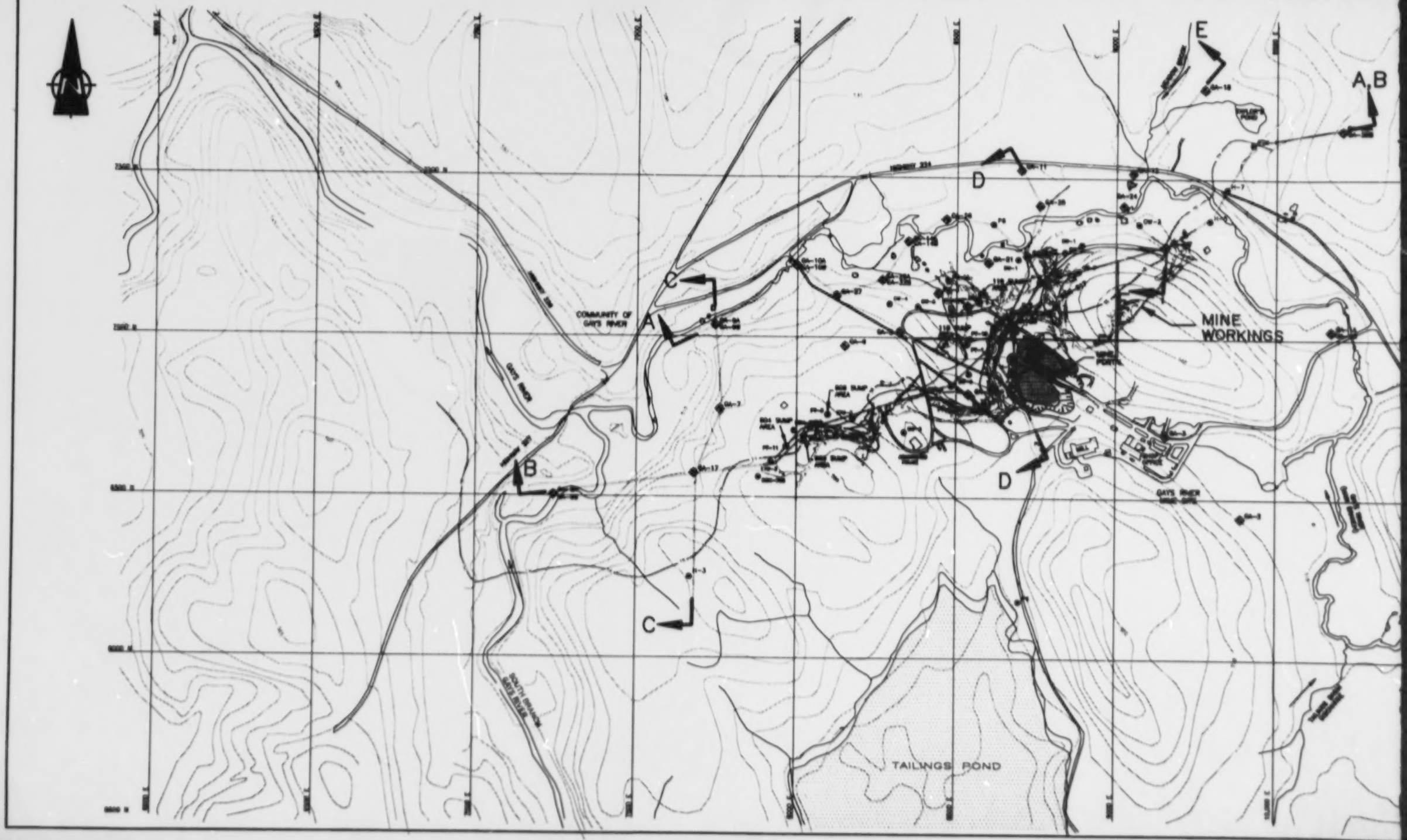
Date NOV. 1991

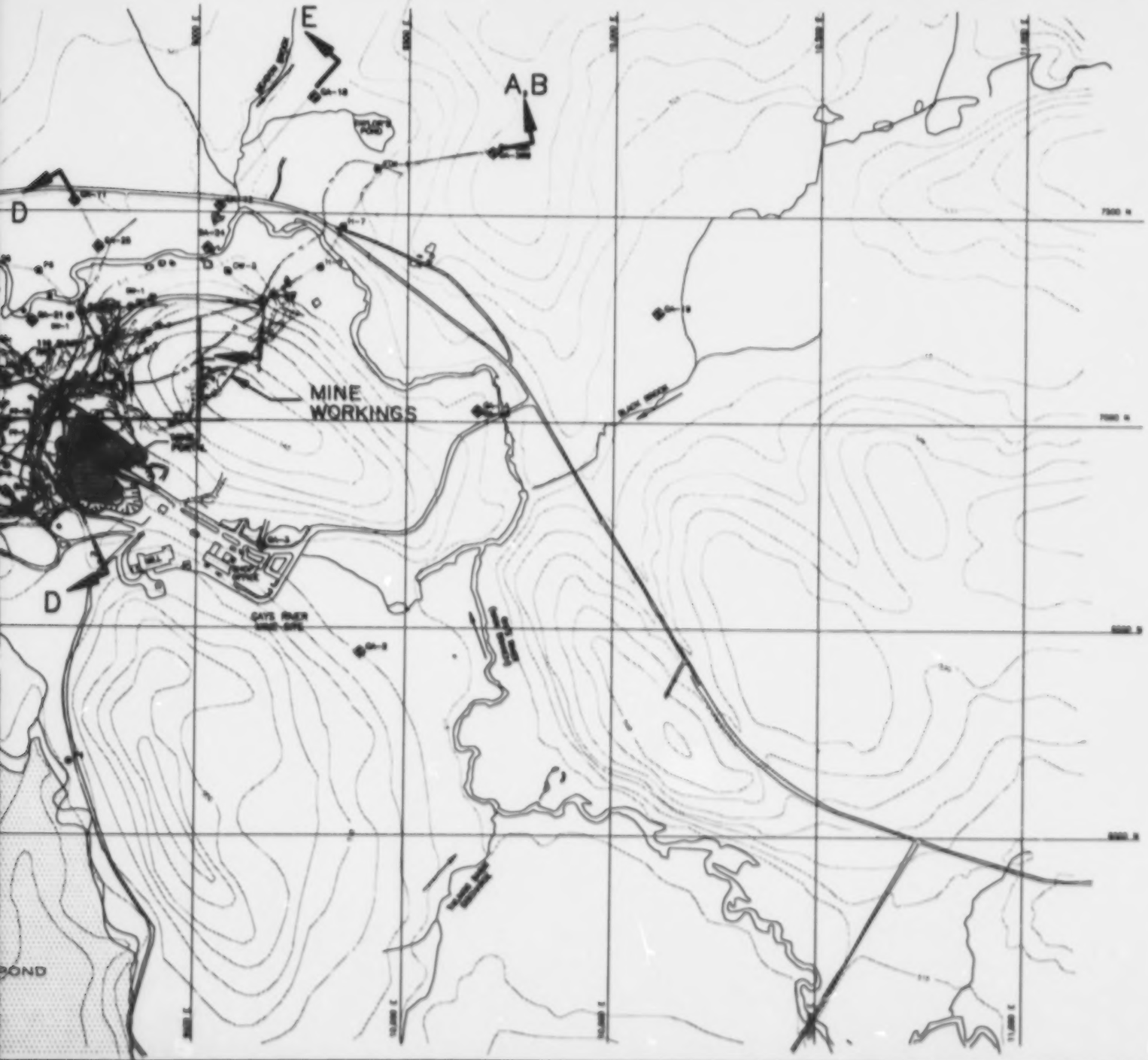
Project 911-1726

Golder Associates

Drawn PL

Chkd


A
B
C
D
E
A,B
MINE
WORKINGS
TAILINGS POND
COMMUNITY OF
GAYS RIVER
GAYS RIVER
SOUTH BRANCH
GAYS RIVER



SITE CONDITIONS AND UNDERGROUND PLAN
GAYS RIVER MINE

FIGURE 2

LEGEND

- BOREHOLE LOCATION IN PLAN (Drilled by Golder Associates Ltd.)
- OBSERVATION WELL LOCATION IN PLAN (Drilled by others)
- ABANDONED OBSERVATION WELL LOCATION IN PLAN (Drilled by others)
- UNDERGROUND HYDRAULIC HEAD MONITORING LOCATION
- SINKHOLES
- TRENCH
- CONTOUR OF GROUND SURFACE ELEVATION IN 5 METRES INTERVALS
- DIRECTION OF SURFACE WATER FLOW
- E — SECTION LOCATION IN PLAN

NOTES

1. ALL ELEVATIONS ARE IN METRES TO MINE DATUM
2. 500.357m MINE DATUM IS MEAN SEA LEVEL
3. FOR SECTIONS A-A TO E-E REFER TO FIGURES 8,9 AND 10.

SCALE

1 : 10,000

0 400 800 metres
200 600 1000

Date NOVEMBER.1991.

Project ..811-1328.....

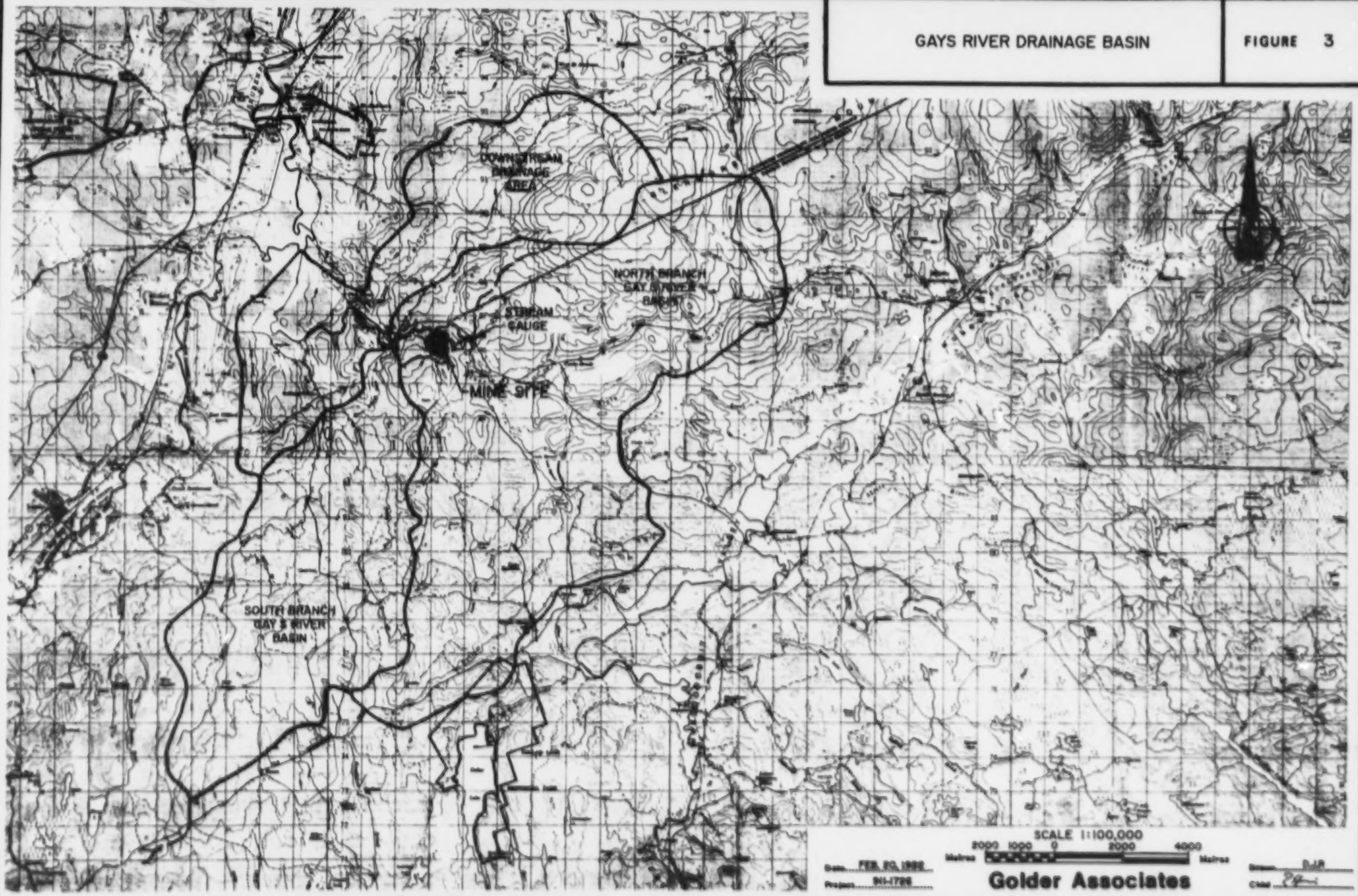
Golder Associates

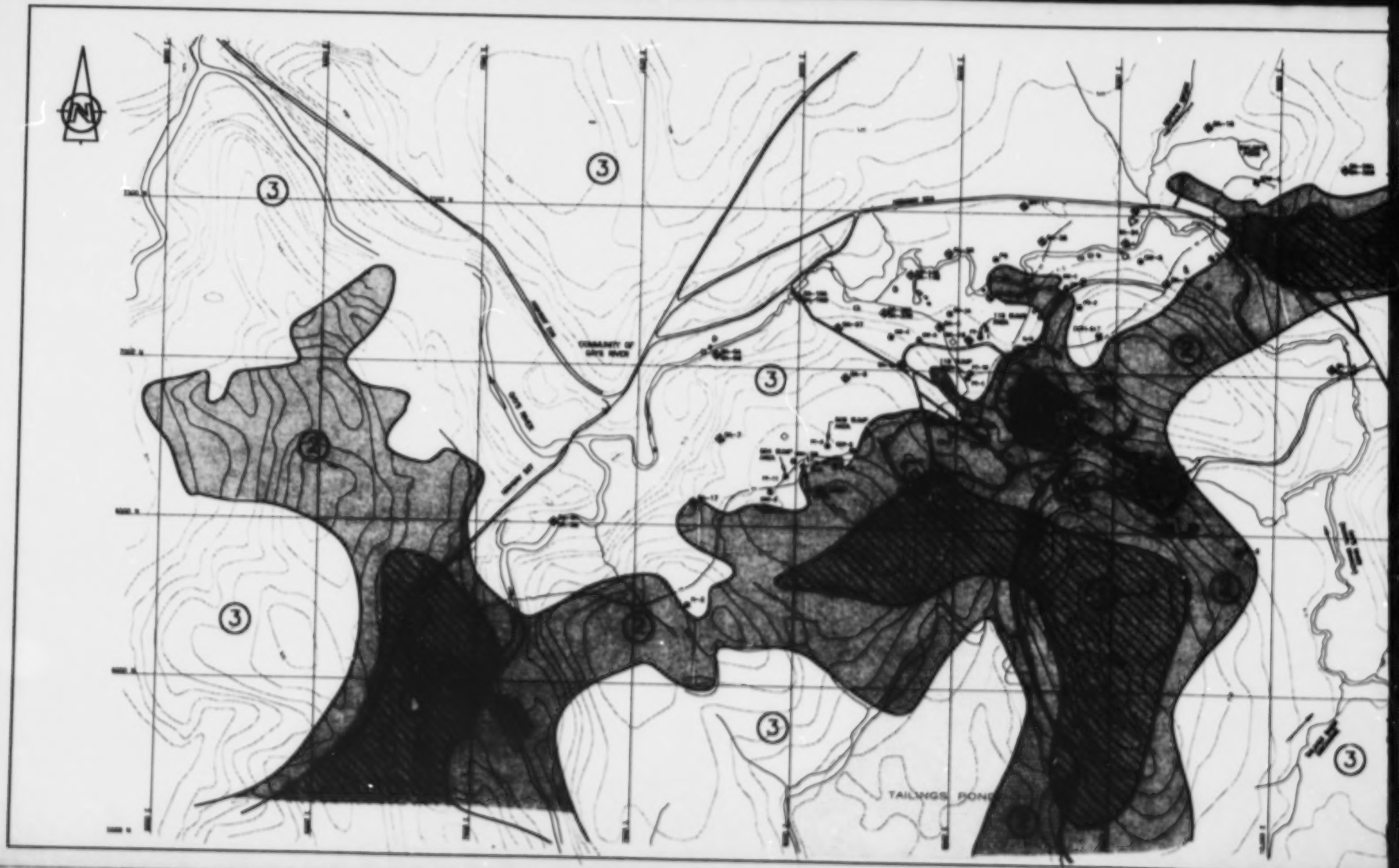
Drawn .TDR.....

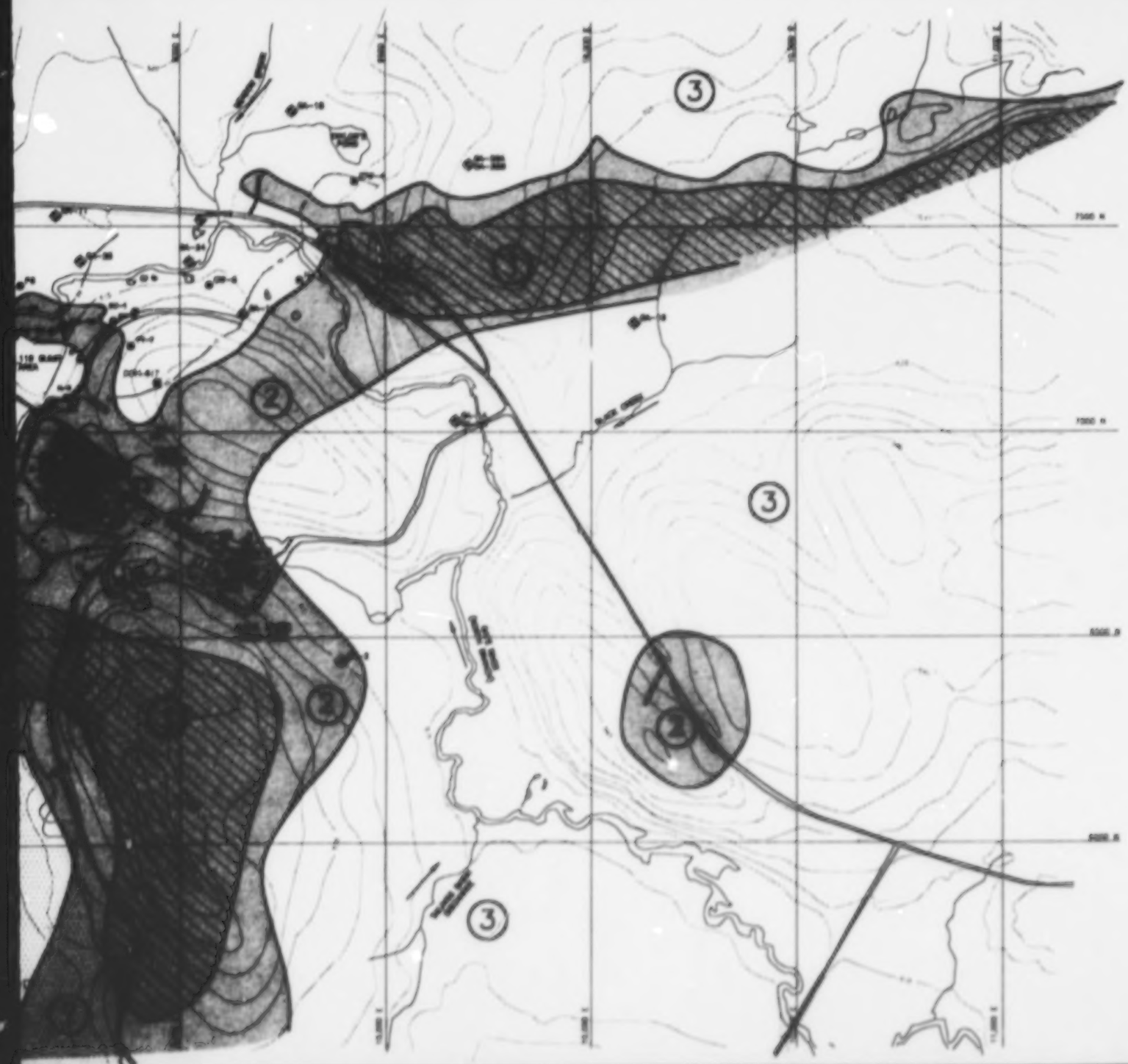
Chkd .....

GAYS RIVER DRAINAGE BASIN

FIGURE 3




N
3
3
3
3
3
3
TAILINGS POND



BEDROCK GEOLOGY

FIGURE 4

LEGEND

- BOREHOLE LOCATION IN PLAN (Drilled by Golder Associates Ltd.)
- OBSERVATION WELL LOCATION IN PLAN (Drilled by others)
- ABANDONED OBSERVATION WELL LOCATION IN PLAN (Drilled by others)
- UNDERGROUND HYDRAULIC HEAD MONITORING LOCATION
- SINKHOLES
- TRENCH
- CONTOUR OF GROUND SURFACE ELEVATION IN 5 METRES INTERVALS
- DIRECTION OF SURFACE WATER FLOW

STRATIGRAPHY

WINDSOR GROUP

3 — Carrolls Corner Formation
Gypsum, Anhydrite, Siltstone, Dolostone, Limestone

2 — Gays River and Macumber Formations
Dolostone, Limestone, Gay's River Orebody

MEGUMA GROUP

Goldenville Formation
Greywacke, Slates, Quartzite

NOTES

1. ALL ELEVATIONS ARE IN METRES TO MINE DATUM
2. 500.357m MINE DATUM IS MEAN SEA LEVEL

SCALE

1 : 10,000

0 200 400 600 800 1000 metres

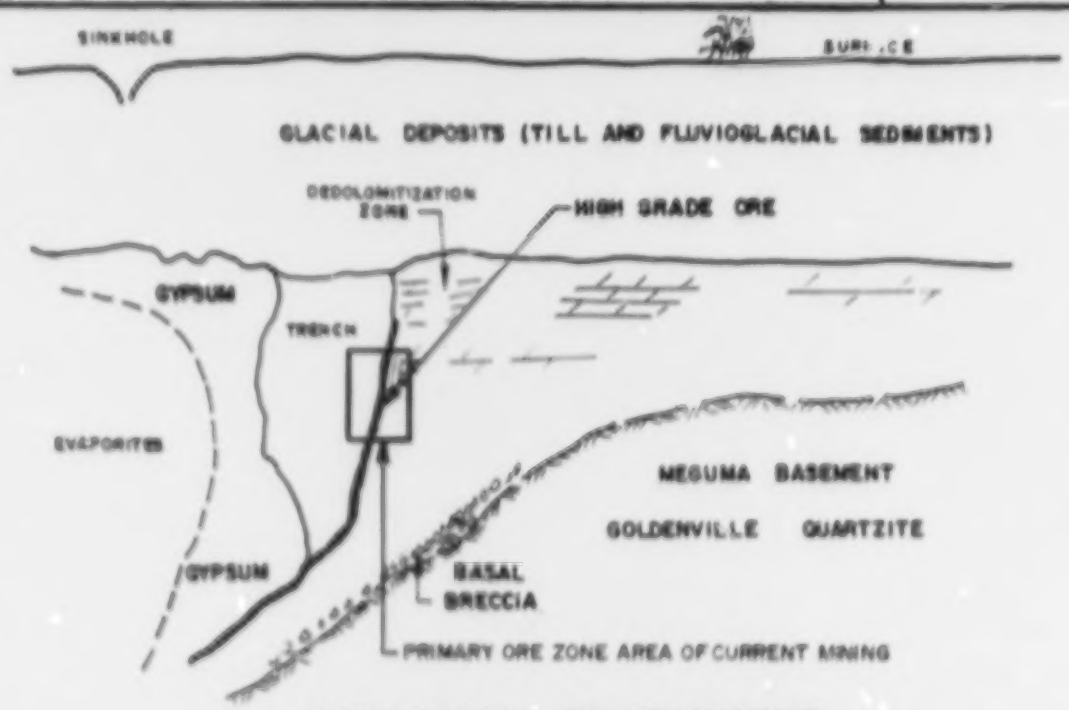
Date NOVEMBER 1991.
Project 911-1228

Golder Associates

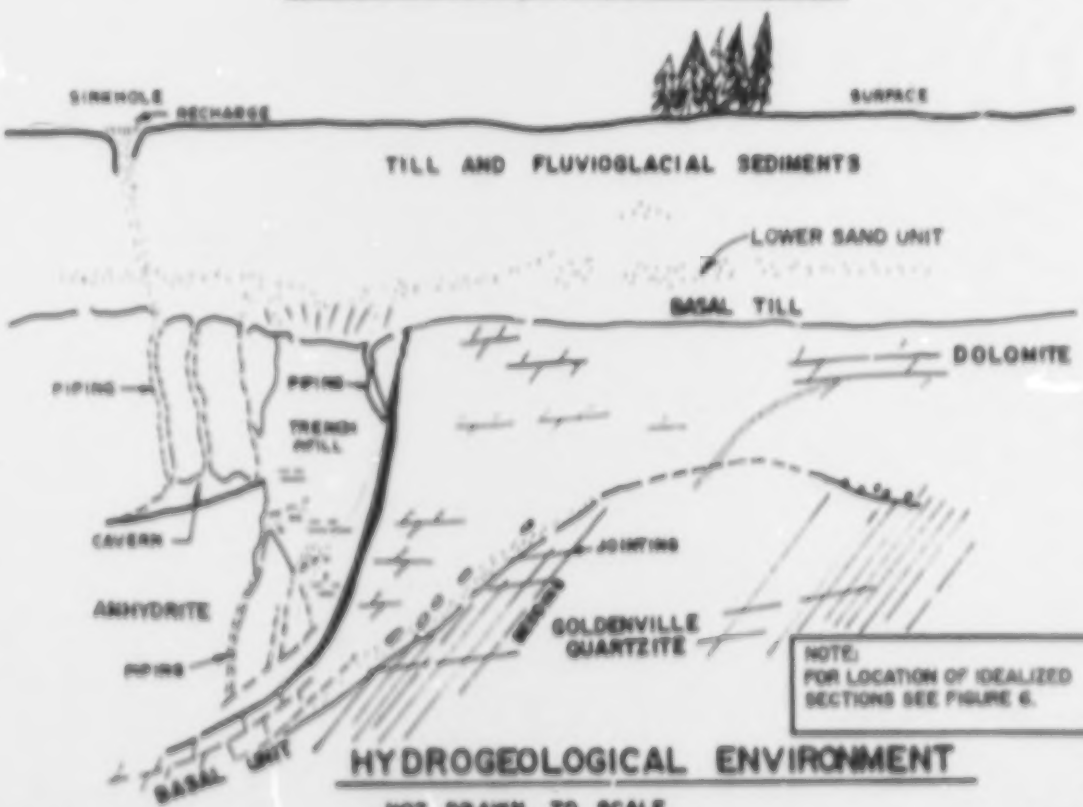
Drawn TDR
Chkd

IDEALIZED SECTIONS SHOWING GEOLOGICAL AND HYDROGEOLOGICAL ENVIRONMENT OF OREBODY

FIGURE 5



GEOLOGICAL ENVIRONMENT



HYDROGEOLOGICAL ENVIRONMENT

NOT DRAWN TO SCALE

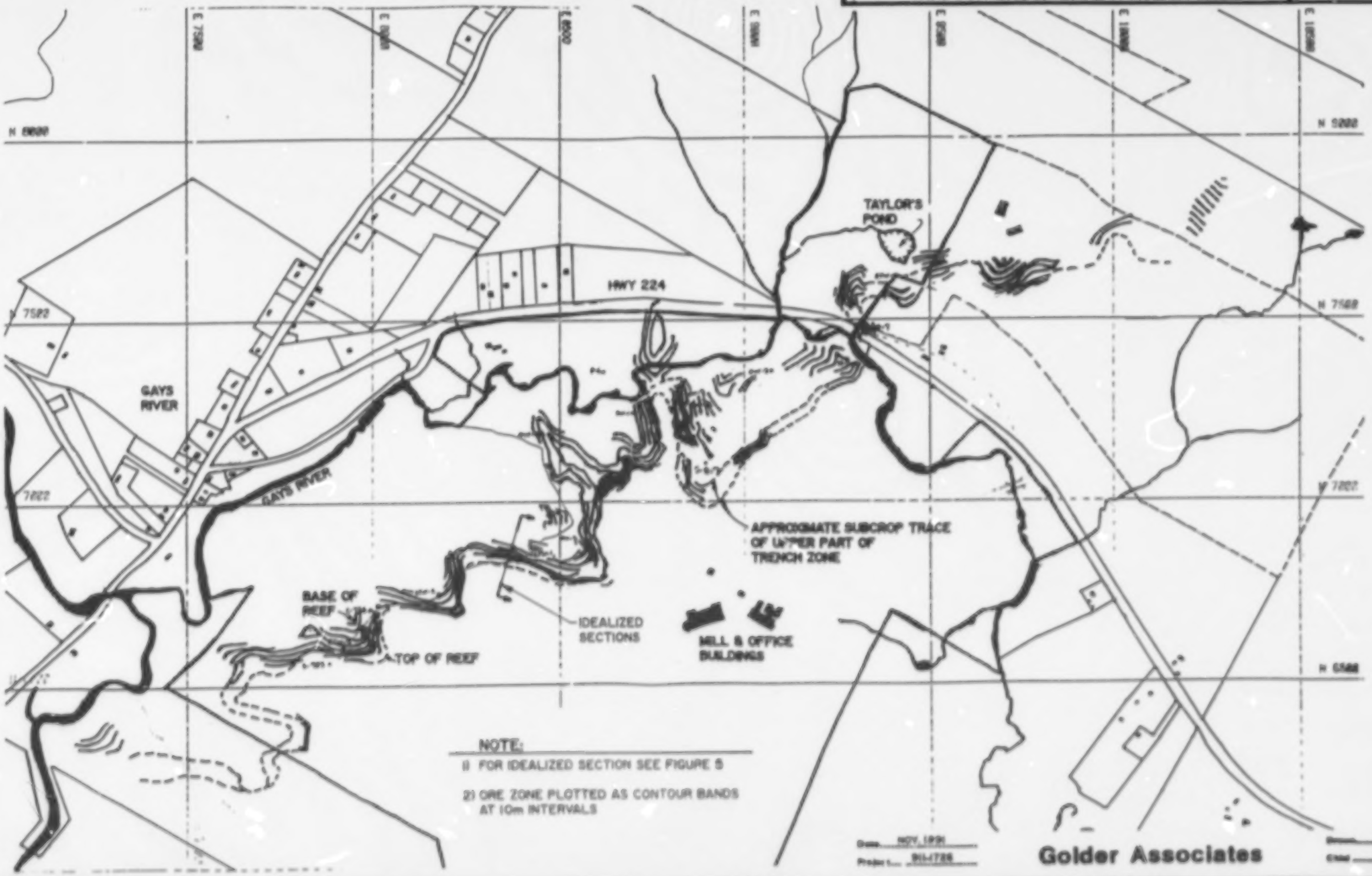
Date NOV.1991
Project No. 911726

Golder Associates

Drawn PL
Chkd

PLAN OF MINE AREA SHOWING COMPLEX GEOMETRY OF ORE ZONE FOLLOWING FOREFRONT REEF FACE OF WINDSOR GROUP CARBONATE ROCKS

FIGURE 6



NOTE:

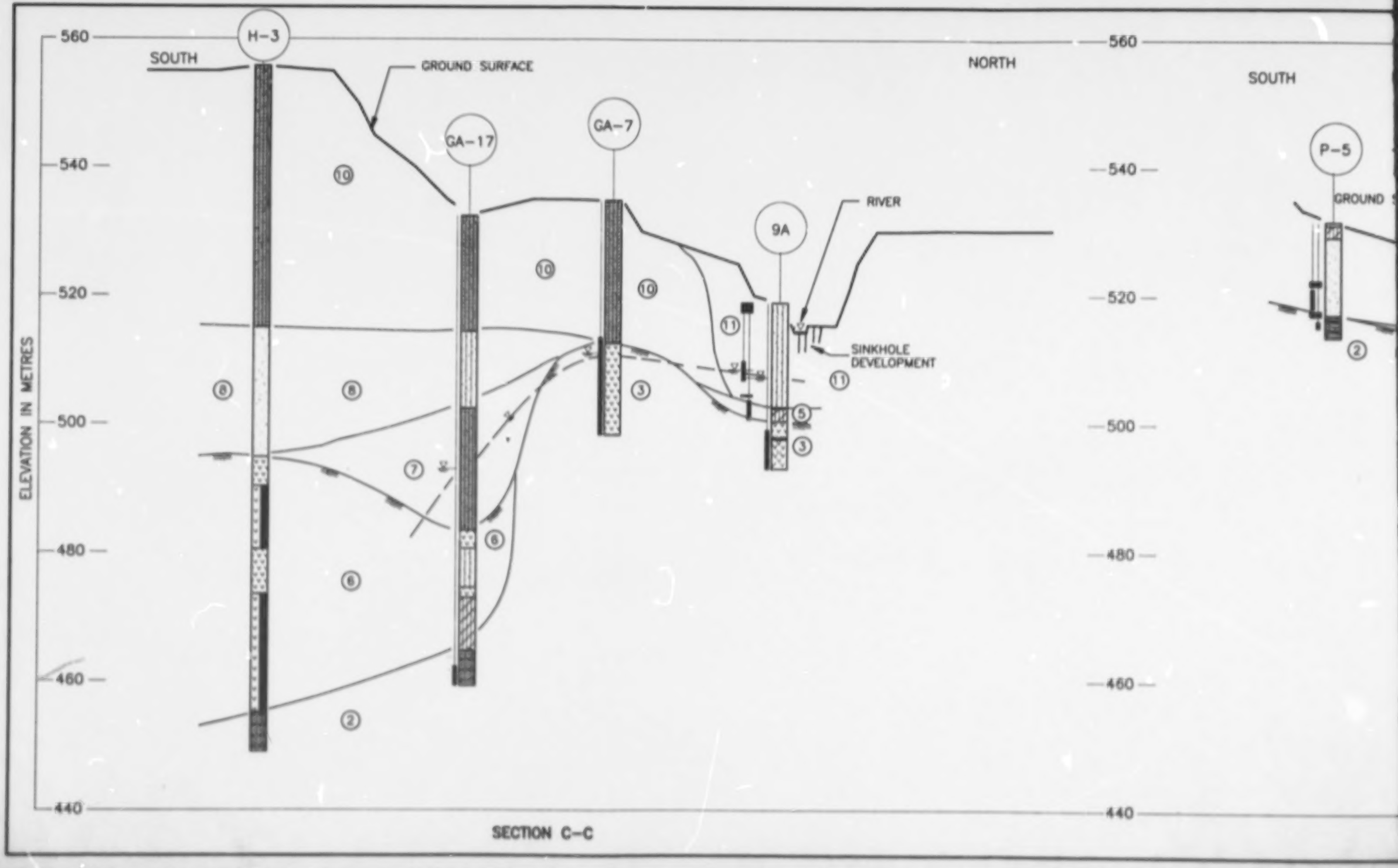
1) FOR IDEALIZED SECTION SEE FIGURE 5

2) ORE ZONE PLOTTED AS CONTOUR BANDS AT 10m INTERVALS

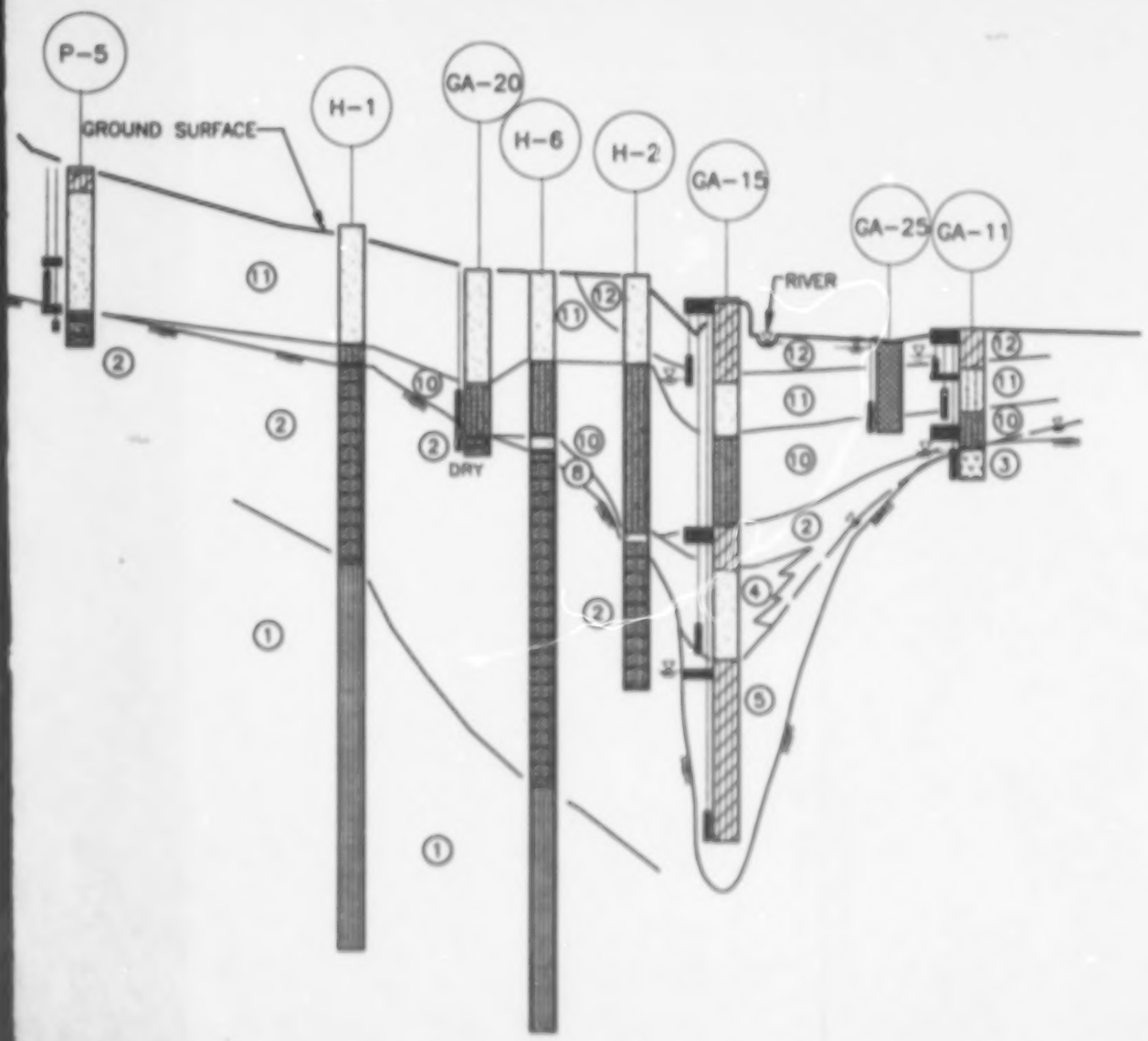
Date NOV 1991
Project 911-1726

Golder Associates

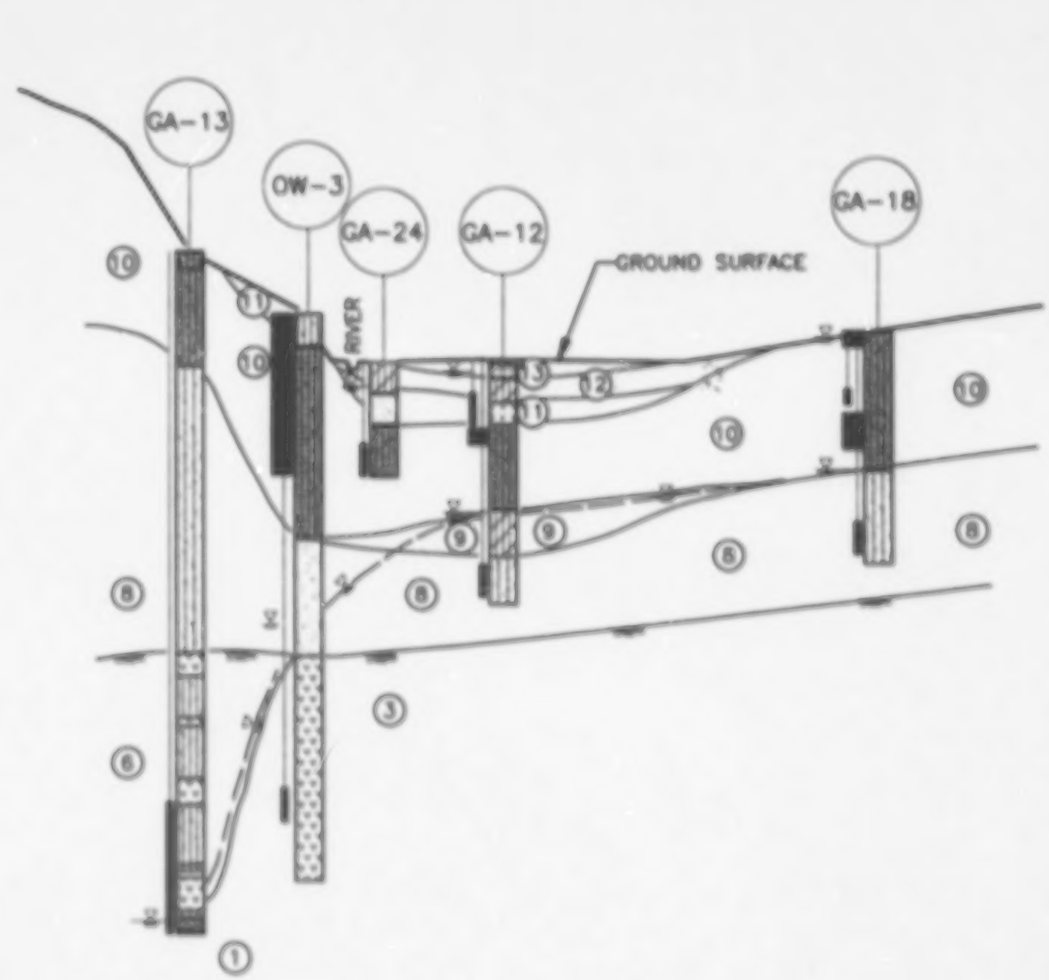
Drawn PL
Chkd TAL RJT


560
540
520
500
480
460
440
ELEVATION IN METRES
SOUTH
H-3
GROUND SURFACE
GA-17
GA-7
9A
RIVER
SINKHOLE DEVELOPMENT
NORTH
560
540
520
500
480
460
440
SOUTH
P-5
GROUND
10
8
7
6
2
11
5
3

SECTION C-C



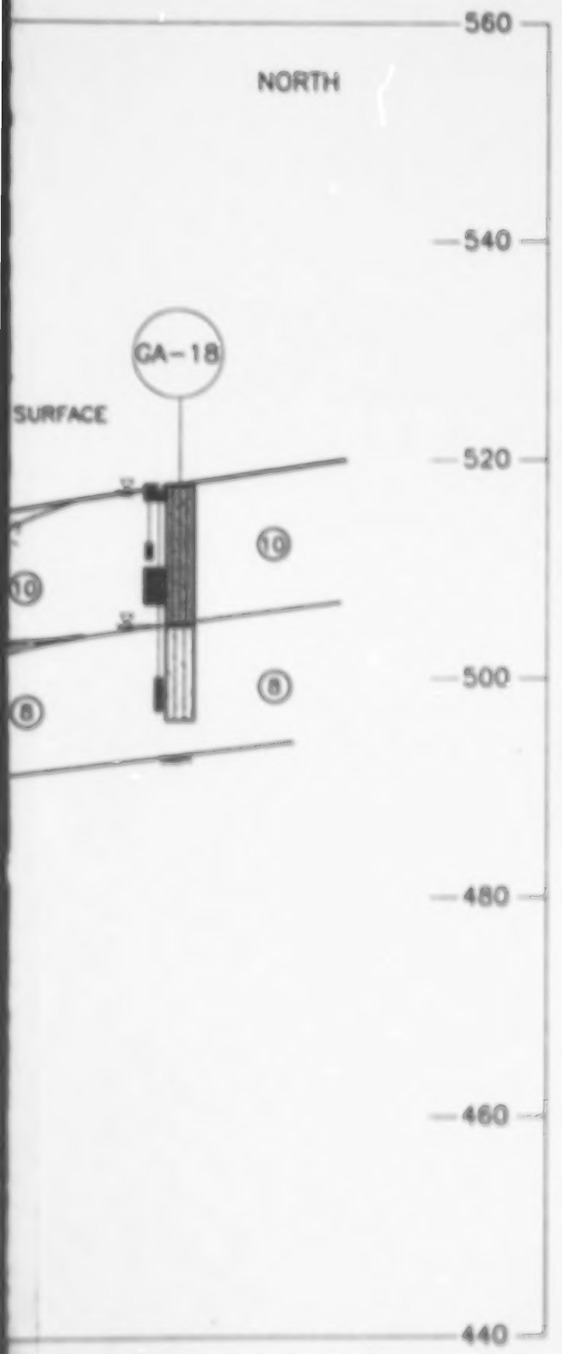
SECTION D–D



SECTION E–E

SECTIONS C–C, D–D, E–E
SCHEMATIC OF OVERBURDEN STRATIGRAPHY AND GROUNDWATER LEVELS

FIGURE 10



STRATIGRAPHY

SYMBOLS – SOILS

UNDIFFERENTIATED | SAND | SILTY SAND | CLAYEY SILT AND SAND | CLAYEY SILT TO SILTY CLAY

SYMBOLS – BEDROCK

CAVERNOUS ZONES | GYPSUM | CARBONATE | QUARTZITE

RECENT SOILS

(13) ALLUVIUM – grey to brown sand, silty sand, peat at surface

PLEISTOCENE SOILS

(12) UPPER LACUSTRINE CLAY – dark red brown, laminated, clayey silt to silty clay, minor interbedded silty sand

(11) UPPER SAND – light to medium brown, interbedded fine to coarse sand, silty sand, occasional beds of gravel

(10) RED TILL – medium red brown clayey silt and sand, some gravel.

(9) LOWER LACUSTRINE CLAY – dark red brown, laminated clayey silt to silty clay, minor interbeds of silty sand.

(8) LOWER SAND – medium brown to grey brown interbedded silty sand, fine to coarse sand, occasional gravel layers.

(7) LOWER TILL – light to dark grey brown, clayey silt and sand, trace gravel.

(6) INFILLED CAVERNOUS GYPSUM – gypsum bedrock with cavernous sections infilled with brown silty sand to sand and gravel, occ. voids.

CRETACEOUS SOILS

(5) CRETACEOUS CLAY – light to dark grey, laminated to massive textured clayey silt and sand, trace to some gravel, sand and gravel clasts dominately comprised of quartz, traces of pyrite.

(4) CRETACEOUS SAND – light grey, medium grained quartz sand

CARBONIFEROUS BEDROCK

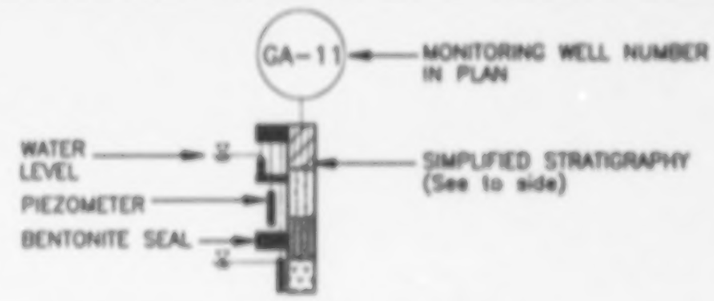
(3) GYPSUM/ANHYDRITE

(2) CARBONATE

ORDOVICIAN BEDROCK

(1) QUARTZITE

LEGEND



NOTE

- WATER LEVEL MEASUREMENTS RECORDED ON SEPT. 25, 1991
- ELEVATIONS ARE TO MINE DATUM
- FOR LOCATION OF SECTIONS REFER TO FIGURE 2.

SCALE

HORIZONTAL 1 : 5000

0 100 200 300 400 500 metres

0 10 20 30 40 50

VERTICAL 1 : 500

Date NOVEMBER 1991

Project 911-1729

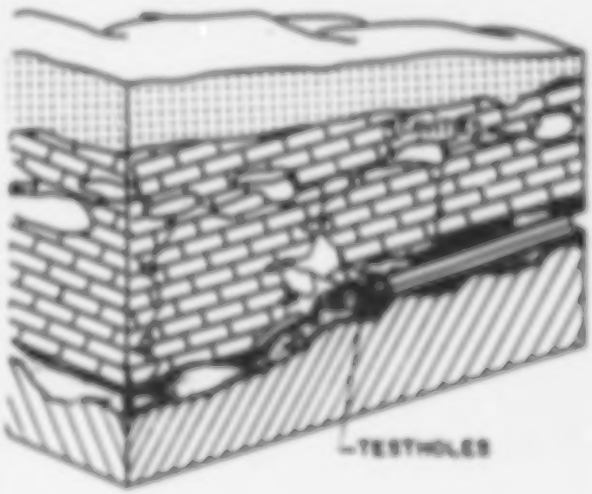
Golder Associates

Drawn

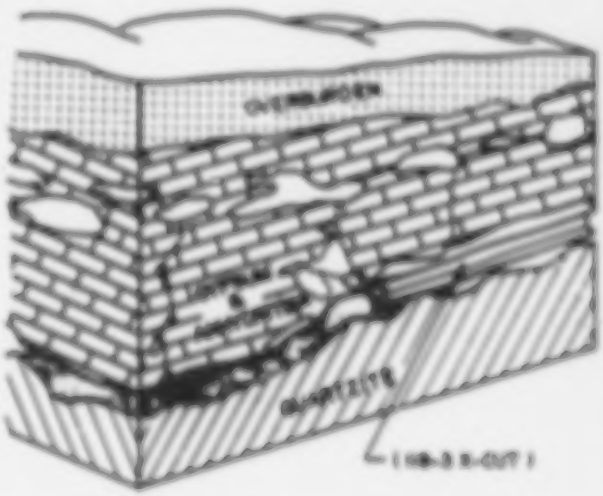
Chkd

POSTULATED SINKHOLE DEVELOPMENT ASSOCIATED WITH DRIFT EXCAVATION INTO KARSTIC ZONE

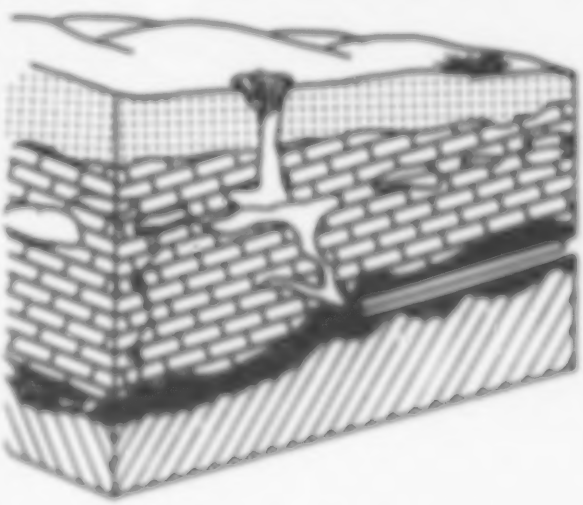
FIGURE 11



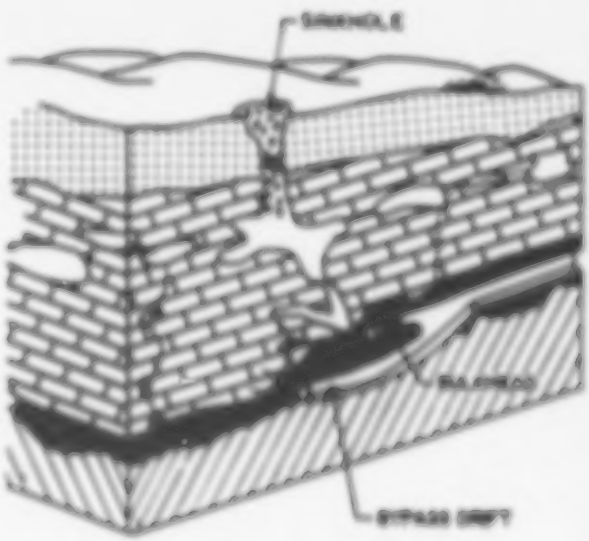
1. The U/G heading is advanced in ore, testholing along the way. The testholes misses the piping in the gypsum.



2. A water bearing pipe in the rock is exposed after a round is blasted.



3. The heading floods with water, sand and mud and a sinkhole forms on surface.



4. The drift is pumped out and a reinforced concrete bulkhead built. A new heading is then driven through waste to bypass the water.

MODIFIED FROM INTERNAL REPORT FROM ESSO RESOURCES LTD.

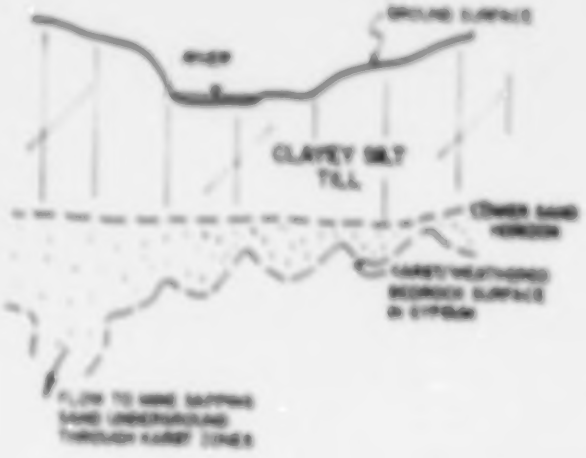
Date NOV. 1991
Project 911-7788

Golder Associates

Drawn PL
Chkd

POSTULATED SEQUENCE OF SINKHOLE DEVELOPMENT THROUGH TILL

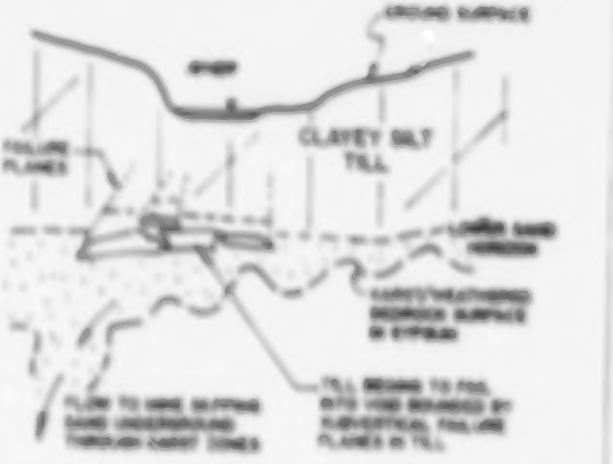
FIGURE 12



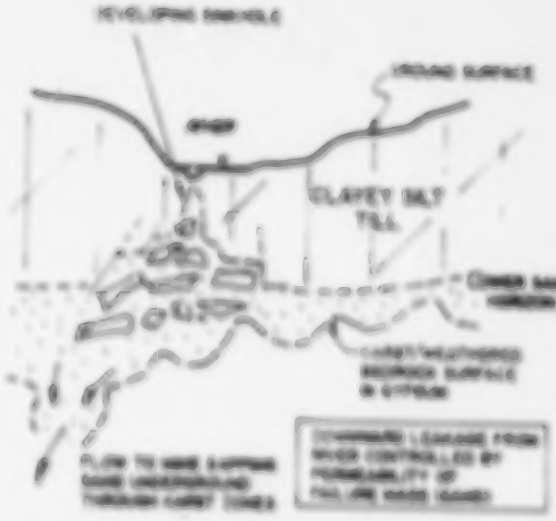
① INITIAL CONDITIONS



② INITIATION OF SINKHOLE DEVELOPMENT



③ SINKHOLE PROGRESSION (CRATER RETREAT)



④ PROGRESSIVE DEVELOPMENT TO POINT OF SURFACE EXPRESSION IN RIVER

Date AAJ 10, 191

Project 91x1708

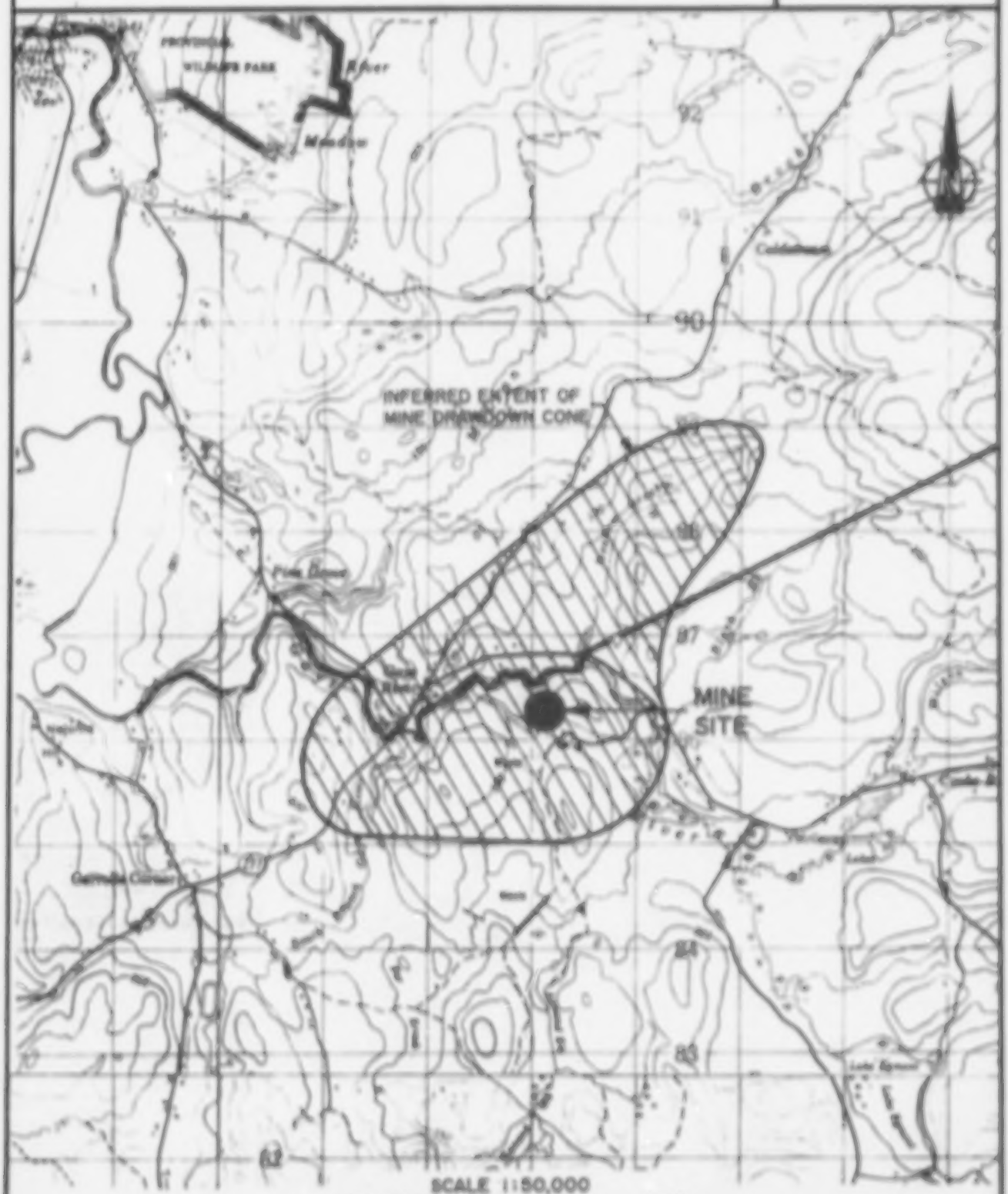
Golder Associates

Drawn SM

Chkd

INFERRED EXTENT OF MINE DRAWDOWN CONE

FIGURE 14



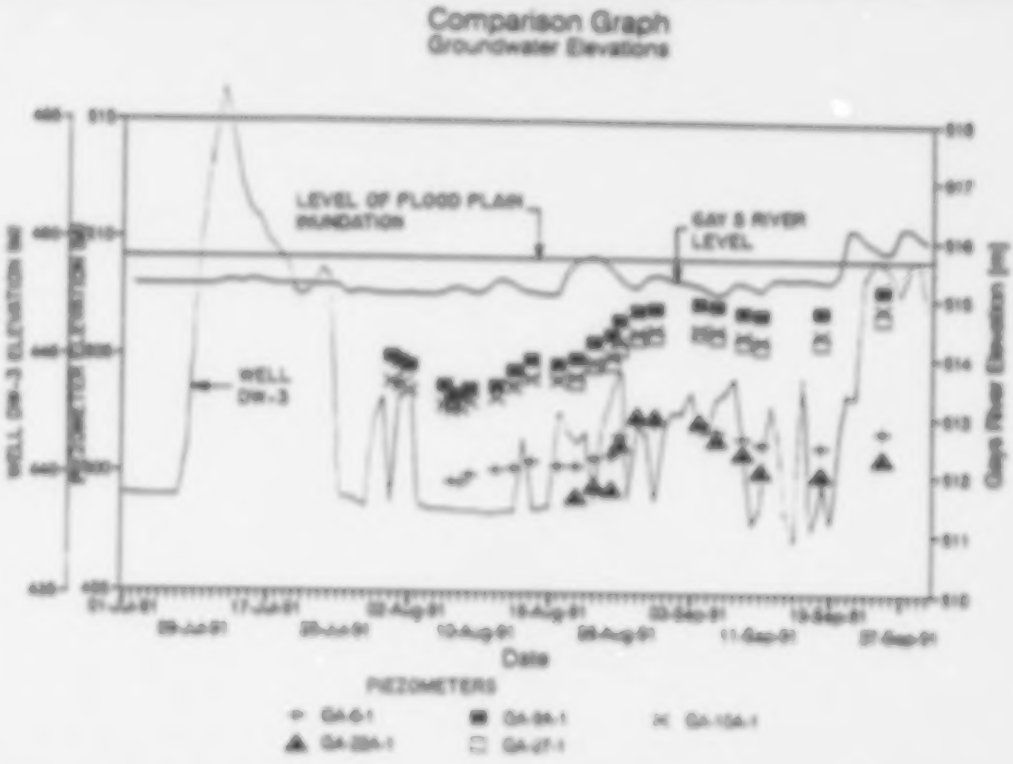
Date FEB. 24, 1992
Project 911-1726

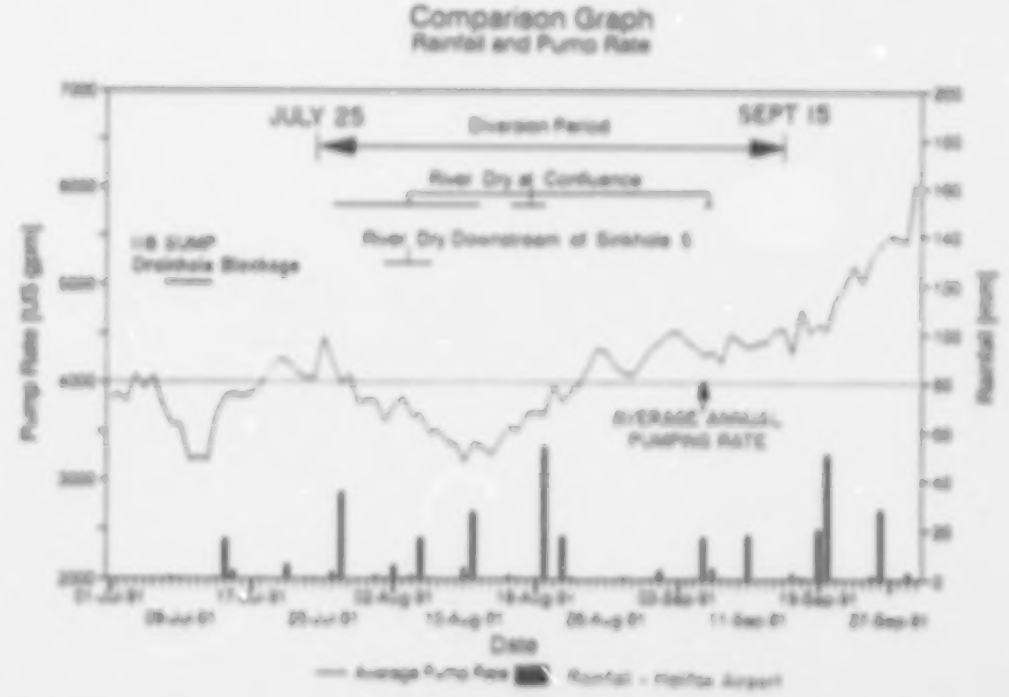
Golder Associates

Drawn D.J.R.
Chkd

TRENDS IN WATERLEVELS, PRECIPITATION AND MINE PUMPING RATES DURING MINE DISCHARGE DIVERSION

FIGURE 15





Date FEB. 21, 1992
Project 911-1726

Golder Associates

Drawn DJR
Chkd

APPENDIX A

SITE INVESTIGATION PROGRAM

APPENDIX A - SITE INVESTIGATION PROGRAM

A.1 OVERVIEW 1

A.2 SITE RECONNAISSANCE 1

A.3 BOREHOLE DRILLING 2
A.3.1 General 2
A.3.2 Augered Boreholes 2
A.3.3 Wash bored/rotary drilled boreholes 3

A.4 PIEZOMETER INSTALLATIONS 4
A.4.1 Piezometer Construction 4
A.4.2 Piezometer Development 5
A.4.3 Piezometer Response Testing 6
A.4.4 Survey Control 7

A.5 GEOPHYSICAL LOGGING 7

A.6 LABORATORY SOIL TESTING 8

A.7 WATER LEVEL MONITORING 8

Following Pg. A-8:

Table A-1 Summary of Overburden Drilling Program Gays River Mine - Nova Scotia
Table A-2 Drilling Procedures Gays River Mine - Nova Scotia
Table A-3 Summary of Piezometer Installations Gays River - Nova Scotia
Table A-4 Piezometer Development and Hydraulic Conductivity Testing

Following Tables:

Record of Boreholes (Boreholes GA-1A to GA-28B Inclusive)
Figure A-1 - Borehole Location Plan Gays River 1991 Overburden Investigation

SITE INVESTIGATION PROGRAM

A.1 OVERVIEW

The overburden drilling program conducted at the Gays River Mine site comprised the following main components:

1) Site reconnaissance to assess site conditions and determine locations for monitoring wells,

2) the supervision of the drilling and soil sampling of thirty-five (35) boreholes at twenty-eight (28) locations shown on Figure A-1,

3) the installation, development, response testing and water level monitoring of forty-nine (49) piezometers installed within the various boreholes,

4) the geophysical logging of fourteen (14) of the Golder boreholes and fifteen (15) pre-existing wells.

5) Following the field program, laboratory grain size classification, moisture content and Atterberg Limits analyses were carried out on selected representative soil samples

The following sections provide a detailed account of these components of the field and laboratory program.

A.2 SITE RECONNAISSANCE

The Gays River mine site was visited on June 28, 1991 by members of the Golder Associates engineering group. The purpose of this visit was to: (1) meet with the engineering/geology personnel at the mine site to discuss the proposed field program and (2) assess the site conditions and establish locations for monitoring wells.

The mine geologist provided the Golder representatives with a tour of the mine site as well as the surrounding area. The mine operations were discussed, including the mine experiences with groundwater conditions.

A.3 BOREHOLE DRILLING

A.3.1 General

Logan Drilling Limited of Stewiacke, Nova Scotia provided the drilling contractor services and all work was directed and supervised in the field by members of Golder Associates engineering staff.

The majority of the overburden drilling was carried out using a CME Model 55 Bombardier mounted power auger drillrig. About midway through the drilling program the decision was made by Westminer (in consultation with Golder Associates) to retain a second drill rig which would be capable of advancing several deep (> 30m) boreholes to increase the rate of progress of the drilling program. Based on discussions with the drilling contractor, a Longyear Model 38 diamond drill equipped for N tricone wash boring was determined to be the most suitable drill rig available and was subsequently mobilized to site. The following paragraphs outline the drilling procedures for both the auger and wash bore drilling.

All borehole locations are shown on Figure A-1 and detailed logs of all boreholes are provided in the Record of Borehole sheets in Appendix A. In those locations where there are two boreholes, A designates the deeper borehole while B represents the shallow borehole. A summary of the drilling program and drilling procedures is provided on Tables A-1 and A-2 in Appendix A respectively.

A.3.2 Augered Boreholes

A total of 31 augered boreholes ranging in depth from about 8.2 to 57.6 m were drilled between July 3 and August 16, 1991. The borehole locations were selected by both Golder Associates and Westminer Canada, and were generally selected to facilitate a detailed characterization of the soil stratigraphy and groundwater levels in key areas.

The borings were advanced using hollow-stem augers (203 mm dia. and 108 mm I.D. dia.). Tricone drilling through the hollow stem augers was also required to advance the boreholes through dense glacial till or bedrock and in some cases, NW casing was also advanced through the augers when refusal to augering was reached. Soil samples were recovered with a standard 51 mm O.D. split barrel sampler at regular intervals of 1.5 to 3.0 m as the borings were advanced. Standard Penetration Tests (SPT) 'N' values were obtained as the sampler was driven. Several (89 mm diameter) shelby tube samples were obtained within the soft clay rich cohesive soils.

Three shallow boreholes, GA-21, GA-24 and GA-25, were drilled entirely under Westminer supervision to provide shallow piezometers only and as such, standard sampling was not undertaken such that the soil stratigraphy was not defined in detail.

A.3.3 Wash bored/rotary drilled boreholes

A total of four (Boreholes GA-5,13,17 and 23) wash bored/rotary drilled boreholes were drilled to depths from about 42 m to 73 m between July 18 and August 6, 1991. The borehole locations were selected in areas of known thick overburden deposits.

The borings were advanced using HW, NW and BW casing. As the drill was not equipped with a cathead and hammer, split spoon samples could not be taken in a conventional manner. Therefore, Boreholes GA-5 and GA-23 were drilled without split spoon sampling and the soil stratigraphy encountered was based entirely on drill cutting samples returned to surface. Although these drilling/sampling methods achieved the goal of expeditiously advancing these boreholes the stratigraphic interpretation was very limited. Therefore, it was decided that a better sampling method would be required to achieve the primary goal of defining the soil stratigraphy. Accordingly, Boreholes GA-13 and GA-17 were drilled with split spoon sampling whereby the sampler was hydraulically pushed with the head of the drillrig at regular 3.0 m intervals as the boreholes were advanced. This sampling method resulted in the procurement of generally good quality soil samples although 'N' values were not obtained.

Drilling problems due to poor drill water circulation were encountered during the washbore drilling. Therefore, Matec brand drilling fluid additive was used by the contractor to enable advancement of BH's GA-5, 13 and 23 at various times during drilling as noted on the borehole records in Appendix A. Revert brand drilling fluid was utilized for Borehole GA-17. This borehole was flushed with chlorine bleach on completion to accelerate the breakdown of the Revert.

A.4 PIEZOMETER INSTALLATIONS

A.4.1 Piezometer Construction

Piezometers were installed within selected stratigraphic horizons in all boreholes in order to obtain groundwater level measurements. The depths and construction details of the wells installed in each borehole are shown on the Record of Borehole sheets and are summarized in Table A-3 in Appendix A. As indicated in Table A-3, a total of forty-nine (49) piezometer wells were installed as part of the field program.

The piezometers were constructed primarily with:

(1) 25 mm inside diameter Schedule 40 PVC plain end (glued) riser pipe and Schedule 40, PVC No. 20 slot PVC intake screen

(2) 51 mm inside diameter Schedule 40 PVC flush thread riser pipe and Schedule 40, PVC No. 20 slope PVC intake screen

Limited quantities of 25 mm inside diameter Schedule 40 PVC flush thread riser pipe and Schedule 40, No. 60 slot PVC intake screen were used, primarily because of material supplier shortages as outlined on Table A-3.

All riser pipe plain end joints were glued during installation. No. 2 silica sand was used to construct filter packs around the piezometer intake screens. The sections of borehole between the sand pack intervals were filled with bentonite gravel chips to seal the piezometers. The completed installations were protected by steel or PVC casings fitted with locking caps (see Table A-3).

A.4.3 Piezometer Development

The piezometers installed in the various boreholes were generally developed shortly after installation. The purpose of the development was to remove drill cuttings from the monitoring intervals and assure that the piezometers were adequately monitoring the respective formation intervals.

The development methods used are summarized on Table A-4 in Appendix A. The majority of well development for the 25 mm in dia. piezometer was carried out by lifting the groundwater to surface with compressed nitrogen gas. Gas purging involved the use of a length of 6 mm dia. polyethylene tubing attached to a nitrogen regulator and bottle at surface. The tubing, with a weight attached to the end, was lowered to the bottom of the piezometer and gas released through the tubing into the well to force water and any drill cuttings up the piezometer riser pipe to surface.

Development involved surging the gas into the piezometers in short duration pulses at pressures of approximately 200 psi. This resulted in a rapid evacuation of the standing water column, thereby inducing strong hydraulic gradients towards the piezometers and flushing silt sized drill cutting particles out of the piezometer and the sand filter and up to surface. This process eventually produced relatively silt free water from the formation.

The majority of development for the 51 mm dia. piezometers was carried out by pumping the groundwater to the surface with a plastic 'Waterra' footvalve attached to the end of 19 mm dia. polyethylene tubing. The tubing is moved up and down at the surface to force water and any drill cuttings through the tubing to the surface. This development method was generally very successful for 51 mm dia. wells less than 20 m deep.

In some of the deeper piezometers, the removal of water using a plastic bailer was required as outlined on Table A-4. Both the gas purging and hand pumping methods are generally less effective with greater depths.

A.4.3 Piezometer Response Testing

In-situ hydraulic conductivity testing generally provides the measurement of the soils ability to transmit water. The tests were carried using either (1) the rising head (bail test) or (2) the falling head (slug test). The results of both test methods were analysed using the Hvorslev interpretation for piezometer recovery data. The results of hydraulic conductivity testing obtained for forty two monitoring wells and the representative stratigraphic horizons are presented in Table A-4.

The testing was carried out following the development of the piezometers. The falling head test method involved filling the piezometer with water and measuring the rate of fall. The rate of fall was recorded either by hand with a co-axial type water level finder or by using a pressure transducer attached to a co-axial cable and data logger. Manual readings with the water level finder were carried out when the rate of fall of the water column was sufficiently slow such that the levels could be recorded. With higher rates of fall, the pressure transducer provided more accurate readings.

The rising head test method involved removing water from the piezometer, in the same manner in which the piezometer was developed and measuring the rate of recovery. The rate of recovery was also recorded manually with a co-axial type water level finder.

Piezometer response tests measure the horizontal hydraulic conductivity of the soil strata where interbedding is significant. For example, within a lacustrine clay unit, the tests will respond to the most permeable soil layers such as silt or sand layers within the clay. The vertical hydraulic conductivity of the test section will be controlled by the clay layers and may be several orders of magnitude lower than the horizontal hydraulic conductivity obtained from the response test.

Response tests are complicated by several factors such as the completion details of the piezometer screens and the stratigraphic horizons straddled by the installation. During completion of the installation, caving of fine grained soils can limit the hydraulic connection between the piezometer and the formation. For example, piezometer response tests for bedrock holes tend to underestimate the hydraulic conductivity in those cases where drill water circulation was lost. Complete loss of circulation occurs within strata with hydraulic conductivities of greater than 10^{-3}

cm/sec. Also, in cases where more than one soil horizon occurs within the completed piezometer interval, the piezometer will generally respond to the most permeable stratum. As such, hydraulic conductivity data obtained from response tests should be used more in terms of assessing relative permeability than attempting to use the data in as stricter quantitative way such as can be done with data from more rigorous methods such as aquifer pump test data.

A.4.4 Survey Control

All survey control data was obtained from the surveying department of the Gays River Mine. It is understood that both elevation and northing/easting data are referenced to mine datum. The mine datum elevation of 500.357 m is equivalent to sea level.

The reference elevation for each monitoring well is the rim of the protective casing, with the protective cap removed. The reference elevations for the wells are provided in Table D-1 of Appendix D and on the Record of Borehole Sheets in Appendix A.

A.5 GEOPHYSICAL LOGGING

A total of fourteen (14) monitoring wells installed during this investigation were logged geophysically using apparent conductivity and natural gamma logging techniques. The results of the geophysical logging of these boreholes is presented in Appendix B.

The geophysical logging was carried out through the completed piezometers in the boreholes installed with 51 mm dia. piezometers only. Due to size restrictions, the boreholes with 25 mm dia. piezometers could not be logged.

The pre-existing monitoring wells were also logged with the natural gamma tool. Conductivity could not be logged because of the steel well casings. Summary logs for these wells are also provided in Appendix B. These logs provide an interpretation of the soil stratigraphy based on the gamma signature as well as previous descriptions provided by the drillers.

The apparent conductivity log is recorded in millisiemens and measures the electrical conductivity (inverse of the electrical resistivity) of the formation. The natural gamma log records the background gamma radiation in counts per second. This radiation is largely emitted from the potassium -40 isotope associated with clay minerals and any traces of uranium and thorium in the soil rock surrounding the borehole.

The stratigraphy previously determined by logging the soil samples obtained from the sampled boreholes were correlated with the geophysical signatures. The geophysical signatures were then used to refine the soil stratigraphy and to correlate with the strata encountered in the wash-bored boreholes where soil sampling was less successful.

A.6 LABORATORY SOIL TESTING

A total of forty (40) soil samples were selected from the major stratigraphic soil horizons and stope infill encountered during the drilling program for laboratory analyses at our Mississauga office. The analyses included grain size classification by sieve and hydrometer, moisture content and 10 selected clayey soils were analysed for Atterberg Limits.

The moisture content and Atterberg Limits data is summarized on Tables C-1 and C-2 respectively and they are also shown graphically on the Records of Boreholes in Appendix A. Grain size curves for the sandy soils were used to determine hydraulic conductivity by the Hazen D_{10} method. The results are presented on Table C-3. Grain size distribution curves for each of the eight major stratigraphic soil units are provided on Figures C-1 to C-8. The grainsize curve for a sandy sample of a stope hanging wall is presented on Figure C-9. A plasticity chart for clayey soil samples is presented on Figure C-10 of Appendix C.

A.7 WATER LEVEL MONITORING

Groundwater levels in piezometers were measured on a regular basis by the surveying department at the Gays River Mine starting from the commencement of the field program. All water levels in the various piezometers were measured manually using a co-axial type electric water level finder that was graduated in 1 cm intervals. The water levels were measured relative to the rim

of the protective casing which is the surveyed elevation reference for the various installations.

Table D-1 of Appendix D summarizes the Golder Associates groundwater level monitoring piezometers including number, location, ground surface elevation, reference elevation (water level measurement reference point) and the stratigraphic horizon monitored. The water level elevation data for the piezometers measured between July 22 and October 30, 1991 is provided on Table D-2. The water level elevations for the pre-existing monitoring wells measured weekly between December 27, 1990 and October 16, 1991 are presented on Table D-3. The water level elevations for the underground drainage hole monitoring locations are presented on Table D-4.

The water level elevation data for all the monitoring locations collected over the monitoring period to date are shown graphically on Figures D-1 to D-50 in Appendix D.

The water levels represented on the Record of Borehole sheets were measured by the mine personnel on September 25, 1991 and are considered to be representative of stable water level conditions for that date.

TABLE A-1

SUMMARY OF OVERBURDEN DRILLING PROGRAM
GAYS RIVER MINE - NOVA SCOTIA

Borehole No.	Ground Surface Elev. (m)	Final Borehole Depth (m)	Drilling	Date Drilled (1991) Start/Compl.	No. of Piezometer and Dia.	Borehole Mud Used	Completion Completed
GA-1A	518.31	22.89	Cbit	10 JULY/11 JULY	two/25 mm	no	no
GA-1B	518.35	8.23	Cbit	4 JULY/4 JULY	one/25 mm	no	no
GA-2	519.54	11.58	Cbit	4 JULY/5 JULY	two/25 mm	no	no
GA-3	523.74	15.24	Cbit	3 JULY/3 JULY	two/25 mm	no	no
GA-4	516.96	19.81	Cbit	19 JULY/19 JULY	one/50 mm	no	yes
GA-5	534.85	42.67	LY30	18 JULY/21 JULY	one/50 mm	yes	yes
GA-6	530.75	33.17	Cbit	1 AUGUS AUG	two/25 mm	no	no
GA-7	534.76	36.58	Cbit	10 AUG/12 AUG	one/50 mm	no	yes
GA-8A	513.97	12.19	Cbit	31 JULY/31 JULY	one/50 mm	no	yes
GA-8B	513.89	3.35	Cbit	31 JULY/31 JULY	one/25 mm	no	no
GA-9A	518.86	25.91	Cbit	29 JULY/30 JULY	one/50 mm	no	yes
GA-9B	519.16	18.75	Cbit	12 AUG/13 AUG	two/25 mm	no	no
GA-10A	516.17	46.94	Cbit	26 JULY/28 JULY	one/50 mm	no	yes
GA-10B	516.33	10.67	Cbit	26 JULY/29 JULY	one/25 mm	no	no
GA-11	515.52	15.24	Cbit	8 JULY/8 JULY	three/25 mm	no	no
GA-12	515.22	22.71	Cbit	6 JULY/7 JULY	two/25 mm	no	no
GA-13	525.25	63.09	LY30	24 JULY/31 JULY	one/25 mm	yes	no
GA-14A	514.00	21.95	Cbit	24 JULY/25 JULY	one/50 mm	no	yes

TABLE A-1 (Cont'd)

Borehole No.	Ground Surface Elev. (m)	Final Borehole Depth (m)	Drillrig	Date Drilled 1991 Start/Compl.	No. of Piezometer and Dia.	Borehole Mud Used	Geophysics Completed
GA-14B	514.03	9.14	CME	24 JULY/25 JULY	one/25 mm	no	no
GA-15	518.56	54.86	CME	11 JULY/16 JULY	three/25 mm	no	no
GA-16	519.23	20.42	CME	16 JULY/17 JULY	one/25 mm	no	no
GA-17	532.37	73.15	LY38	1 AUG/6 AUG	one/25 mm	yes	no
GA-18	517.77	21.56	CME	9 JULY/9 JULY	two/25 mm	no	no
GA-19	517.28	15.24	CME	6 JULY/6 JULY	three/25 mm	no	no
GA-20	521.48	18.74	CME	20 JULY/21 JULY	one/50 mm	yes	yes
GA-21	514.11	9.14	CME	20 JULY/20 JULY	one/50 mm	no	yes
GA-22A	518.16	36.58	CME	8 AUG/9 AUG	one/50 mm	no	yes
GA-22B	518.54	9.14	CME	21 JULY/21 JULY	one/50 mm	yes	no
GA-23	535.63	67.06	LY38	21 JULY/23 JULY	one/50 mm	yes	yes
GA-24	514.98	10.67	CME	22 JULY/22 JULY	one/50 mm	no	yes
GA-25	514.25	9.14	CME	23 JULY/23 JULY	one/50 mm	no	yes
GA-26	514.63	9.14	CME	23 JULY/24 JULY	one/50 mm one/25 mm	no	no
GA-27	527.33	36.88	CME	6 AUG/8 AUG	one/50 mm	no	yes
GA-28A	540.53	57.61	CME	14 AUG/16 AUG	one/50 mm	no	yes
GA-28B	540.65	12.3	CME	14 AUG/16 AUG	one/25 mm	no	no

TABLE A-2

DRILLING PROCEDURES
GAYS RIVER MINE - NOVA SCOTIA

BOREHOLE NUMBER	DRILLRIG	DRILLING PROCEDURES		
		DEPTH INTERVAL (m)	DRILLING METHOD	HOLE DIAMETER (mm)
GA-1A	CME 55	0.0 - 18.3 18.3 - 22.9	Hollow Stem Auger	203
GA-1B		0.0 - 8.23	Tricone	203
GA-2	CME 55	0.0 - 11.6	Hollow Stem Auger	203
GA-3	CME 55	0.0 - 15.2	Hollw Stem Auger	203
GA-4	CME 55	0.0 - 16.8 16.8 - 19.8	Hollow Stem Auger Tricone	203 83
GA-5	CME 55	0.0 - 39.6 39.6 - 42.7	Hollow Stem Auger Tricone	203 83
GA-6	CME 55	0.0 - 22.3 22.3 - 48.2 48.2 - 55.2	Hollow Stem Auger NW Casing Tricone	203 83
GA-7	CME 55	0.0 - 22.9 22.9 - 36.6	Hollow Stem Auger Tricone	203 83
GA-8A	CME 55	0.0 - 4.3 4.3 - 12.2	Hollow Stem Auger Tricone	203 83
GA-8B	CME 55	0.0 - 3.4	Solid Stem Auger	150
GA-9A	CME 55	0.0 - 12.2 12.2 - 18.6 18.6 - 25.9	Hollow Stem Auger NW Casing Tricone	203 89 83
GA-9B	CME 55	0.0 - 12.2 12.2 0 18.3	Hollow Stem Auger NW Casing	203 89
GA-10A	CME 55	0.0 - 15.2 15.2 - 46.9	Hollow Stem Auger NW Casing	203 89
GA-10B	CME 55	0.0 - 10.7	Hollow Stem Auger	203
GA-11	CME 55	0.0 - 12.2 12.2 - 15.2	Hollow Stem Auger Tricone	89 73
GA-12	CME 55	0.0 - 22.7	Hollow Stem Auger	203
GA-13	LONGYEAR 38	0.0 - 21.3 21.3 - 63.1	NW Casing BQ Casing	89 73
GA-14	CME 55	0.0 - 15.24 15.24 - 16.0 16.0 - 21.9	Hollow Stem Auger NW Casing Tricone	203 89 83

TABLE A-2 (Cont'd)

BOREHOLE NUMBER	DRILL RIG	DRILLING PROCEDURES		
		DEPTH INTERVAL (m)	DRILLING METHOD	HOLE DIAMETER (mm)
GA-15	CME 55	0.0 - 19.8 19.8 - 30.5 30.5 - 54.9	Hollow Stem Auger HW Casing NW Casing	203 114 89
GA-16	CME 55	0.0 - 17.4 17.4 - 20.4	Hollow Stem Auger Tricone	203 83
GA-18	CME 55	0.0 - 19.8 19.8 - 21.3	Hollow Stem Auger Tricone	203 83
GA-19	CME 55	0.0 - 10.7 10.7 - 15.2	Hollow Stem Auger Tricone	203 83
GA-20	CME 55	0.0 - 15.2 15.2 - 18.7	Hollow Stem Auger Tricone	203 83
GA-21	CME 55	0.0 - 9.1	Hollow Stem Auger	203
GA-22A	CME 55	0.0 - 18.3 18.3 - 33.5	Hollow Stem Auger NW Casing	203 89
GA-22B	CME 55	0.0 - 9.1	Hollow Stem Auger	203
GA-23	LONGYEAR 38	0.0 - 65.8 65.8 - 67.1	NW Casing Tricone	89 83
GA-24	CME 55	0.0 - 10.7	Hollow Stem Auger	203
GA-25	CME 55	0.0 - 9.1	Hollow Stem Auger	203
GA-26	CME 55	0.0 - 9.1	Hollow Stem Auger	203
GA-27	CME 55	0.0 - 22.9 22.9 - 36.9	Hollow Stem Auger NW Casing	203 89
GA-28	CME 55	0.0 - 16.8 16.8 - 18.3 18.3 - 57.6	Hollow Stem Auger NW Casing Tricone	203 89 83

TABLE A-3

SUMMARY OF PIEZOMETER INSTALLATIONS
GAYS RIVER MINE, NOVA SCOTIA

Piezometer	Ground Surface Elevation (m)	Sand Pack Elevation (From/To) (m)	Screen Elevation (From/To) (m)	Screen I.D. (mm) and Slot	Protective Casing (Type/Stick-up m)	PVC Below Top of Casing (m)
1A-1	518.31	503.4 - 495.4	497.0 - 495.5	25/20	PVC/0.43	0.27
1A-2	518.31	516.8 - 504.9	506.4 - 504.9	25/20	PVC/0.43	0.02
1B-1	518.35	516.9 - 510.2	513.6 - 510.6	25/20	Not Installed	+0.38
2-1	519.54	511.56 - 508.0	511.3 - 508.28	25/20	PVC/0.54	0.20
2-2	519.54	518.3 - 512.3	516.5 - 513.4	25/20	PVC/0.54	0.25
3-1	523.74	518.1 - 508.5	511.6 - 508.5	25/20	PVC/0.76	0.51
3-2	523.74	522.2 - 519.02	522.2 - 519.2	25/20	PVC/0.76	0.56
4-1	516.96	515.5 - 497.2	503.2 - 497.2	51/20	PVC/0.51	0.19
5-1	534.86	533.3 - 492.2	533.3 - 492.2	51/20	PVC/0.52	0.16
6-1	539.75	504.1 - 484.9	504.1 - 484.9	25/20	Steel/0.50	0.07
6-2	539.75	538.2 - 505.0	538.2 - 505.0	25/20	Steel/0.50	0.14
7-1	534.76	532.9 - 498.2	513.4 - 498.2	51/20	Steel/0.56	0.04
8A-1	513.97	508.5 - 501.8	507.9 - 501.8	51/20	Steel/0.52	0.15
8B-1	513.99	515.5 - 510.4	512.2 - 510.4	25/20	Steel/0.67	0.12
9A-1	518.86	517.3 - 493.0	499.1 - 493.0	51/20	Steel/0.65	0.20
9B-1-1	519.16	504.6 - 500.7	504.0 - 507.0	25/20	Steel/0.27	0.16
9B-2-2	519.16	517.7 - 504.83	510.0 - 507.0	25/20	Steel/0.27	0.16
10A-1	516.17	497.3 - 469.3	475.4 - 469.3	51/20	Steel/0.65	0.19
10B-1	516.35	514.7 - 505.5	507.1 - 505.5	25/20	Steel/0.62	0.08

TABLE A-3 (cont'd)

SUMMARY OF PIEZOMETER INSTALLATIONS
GAYS RIVER MINE, NOVA SCOTIA

Piezometer	Ground Surface Elevation (m)	Sand Pack Elevation (From/To) (m)	Screen Elevation (From/To) (m)	Screen I.D. (mm) and Slot	Protective Casing (Type/Stick-up m)	PVC Below Top of Casing (m)
11-1	515.52	503.3 - 505.3	504.2 - 500.3	25/20	PVC/0.53	0.41
11-2	515.52	510.34 - 505.8	409.4 - 506.4	25/20	PVC/0.53	0.46
11-3	515.52	514.02 - 511.0	512.5 - 510.95	25/20	PVC/0.53	0.46
12-1	515.22	507.3 - 492.5	496.2 - 493.2	25/20	PVC/0.61	0.21
12-2	515.22	514.02 - 508.8	512.2 - 509.1	25/20	PVC/0.61	0.11
13-1	525.25	503.9 - 462.2	474.4 - 462.2	25/20	PVC/0.72	0.10
14A-1	514.00	503.3 - 492.1	501.2 - 492.1	51/20	PVC/0.51	0.13
14B-1	514.03	512.5 - 504.9	507.9 - 504.9	25/20	PVC/0.48	0.03
15-1	518.56	480.2 - 463.4	466.4 - 463.4	25/60	PVC/0.34	0.16
15-2	518.56	493.9 - 480.6	485.64 - 482.6	25/60	PVC/0.34	0.11
15-3	518.56	512.8 - 509.7	517.1 - 495.4	25/20	PVC/0.34	0.05
16-1	519.23	517.7 - 498.8	504.3 - 501.3	25/20	PVC/0.57	0.22
17-1	532.37	524.8 - 459.3	477.6 - 459.3	25/20	Steel/0.40	0.28
18-1	517.77	506.8 - 496.2	500.1 - 497.0	25/20	PVC/0.29	0.25
18-2	517.77	516.3 - 509.9	512.4 - 510.9	25/20	PVC/0.29	0.38
19-1	517.28	506.3 - 502.0	505.1 - 502.0	25/20	PVC/0.59	0.30
19-2	517.28	510.9 - 509.9	510.3 - 507.2	25/20	PVC/0.59	0.32
19-3	517.28	515.8 - 511.5	514.7 - 511.6	25/20	PVC/0.59	0.49

TABLE A-3 (cont'd)

SUMMARY OF PIEZOMETER INSTALLATIONS
GAYS RIVER MINE, NOVA SCOTIA

Piezometer	Ground Surface Elevation (m)	Sand Pack Elevation (From/To) (m)	Screen Elevation (From/To) (m)	Screen I.D. (mm) and Slot	Protective Casing (Type/Stick-up m)	PVC Below Top of Casing (m)
20-1	521.48	520.0 - 502.7	515.4 - 503.2	51/20	PVC/0.70	0.23
21-1	514.11	512.6 - 505.0	508.0 - 505.0	51/20	PVC/0.42	0.25
22A-1	518.16	516.7 - 481.7	487.7 - 481.7	51/20	Steel/0.66	0.27
22B-1	518.54	517.0 - 509.4	512.4 - 509.4	51/20	PVC/0.61	0.12
23-1	535.63	534.1 - 468.6	474.7 - 468.6	51/20	PVC/0.52	0.18
24-1	514.98	513.5 - 504.3	507.4 - 504.3	51/20	PVC/0.58	0.21
25-1	514.25	508.2 - 505.1	512.7 - 505.1	51/20	PVC/0.33	0.13
26-1	514.63	510.7 - 505.5	508.5 - 505.5	51/20	PVC/0.46	0.16
26-2	514.63	513.6 - 511.3	512.8 - 511.3	25/20	PVC/0.46	0.13
27-1	527.33	512.1 - 490.5	496.5 - 490.5	51/20	Steel/0.35	0.15
28A-1	540.53	538.7 - 482.9	498.4 - 482.9	51/20	Steel/0.40	0.20
28B-1	540.65	539.2 - 528.4	534.5 - 528.4	25/20	Steel/0.58	0.18

TABLE A-4

PIEZOMETER DEVELOPMENT AND HYDRAULIC CONDUCTIVITY TESTING

Borehole Number	Development Method	Response Test	Hydraulic Conductivity (cm/s)	Representative* Stratigraphic Horizons
1A-1	Nitrogen	Falling Head	1.4×10^{-7}	Gypsum
1A-2	Nitrogen	Falling Head	2.4×10^{-6}	Red Till
1B-1	Nitrogen	Falling Head	2.3×10^{-7}	Red Till
2-1	Nitrogen	Rising Head	7.3×10^{-5}	Sand Layer in Red Till
2-2	Nitrogen	Rising Head	9.1×10^{-6}	Sand Layer in Red Till
3-1	Nitrogen	Falling Head	1.0×10^{-5}	Upper Sand
3-2	Nitrogen	Falling Head	1.0×10^{-5}	Surface Fill
4-1	Piezometer Dry	-	-	Upper Sand/Carbonate
5-1	Plastic Bailer	Rising Head	2.9×10^{-6}	Gypsum
6-1	Undeveloped	Falling Head	$> 1.0 \times 10^{-4}$	Gypsum
6-2	Undeveloped	Falling Head	$> 1.0 \times 10^{-4}$	Lower Sand
7-1	Plastic Bailer	Rising Head	1×10^{-9}	Gypsum
8A-1	Watera	Falling Head	1.0×10^{-3}	Gypsum
8B-1	Nitrogen	Falling Head	1.0×10^{-4}	Alluvium
9A-1	Watera Foot Valve	Falling Head	6.1×10^{-4}	Gypsum
9B-1	Nitrogen	Rising Head	$\sim 1.0 \times 10^{-5}$	Upper Sand
9B-2	Piezometer Dry		-	Upper Sand
10A-1	Waterra	Falling Head	5.9×10^{-5}	Gypsum/Cret. Sand
10B-1	Nitrogen	Falling Head	1.1×10^{-4}	Upper Sand
11-1	Nitrogen	-	-	Gypsum/Red Till
11-2	Piezometer Dry	-	-	Upper Sand
11-3	Nitrogen	Rising Head	1.8×10^{-5}	Upper Lac. Clay
12-1	Nitrogen	Falling Head	6.8×10^{-5}	Lower Sand
12-2	Nitrogen	Falling Head	1.6×10^{-5}	Upper Sand
13-1	Plastic Bailer	Falling Head	$> 1.0 \times 10^{-3}$	Cavern Infill/Karst Void/Carbonate
14A-1	Watera	Falling Head	1.4×10^{-6}	Gypsum

TABLE A-4 (Cont'd)

Borehole Number	Development Method	Response Test	Hydraulic Conductivity (cm/s)	Representative* Stratigraphic Horizons
14B-1	Nitrogen	Falling Head	5.2×10^{-6}	Upper Sand
15-1	Nitrogen	Falling Head	-	Cret. Clay
15-2	Nitrogen	Falling Head	2.8×10^{-5}	Cret. Sand
15-3	Nitrogen	Falling Head	1.5×10^{-3}	Upper Sand
16-1	Nitrogen	Unsuccessful	-	Carbonate
17-1	Not Attempted	Falling Head	$> 1.0 \times 10^{-3}$	Cavern Infill/Karst Void/Carbonate
18-1	Nitrogen (S)	Falling Head	2.3×10^{-4}	Lower Sand
18-2	Nitrogen (S)	Falling Head	$\sim 1.0 \times 10^{-8}$	Red Till
19-1	Nitrogen (S)	Falling Head	1.9×10^{-5}	Gypsum
19-2	Nitrogen (S)	Falling Head	1.5×10^{-3}	Sand Layer in Lac. Clay
19-3	Nitrogen (S)	Falling Head	2.8×10^{-4}	Upper Lac. Clay/Sand Alluvium
20-1	Piezometer Dry	-	-	Carbonate
21-1	Waterra	Falling Head	7.4×10^{-4}	Upper Sand
22A-1	Plastic Bailer	Rising Head	2.5×10^{-4}	Gypsum
22B-1	-	-	-	Upper Sand
23-1	Piezometer Dry	Falling Head	5.4×10^{-4}	Carbonate
24-1	Waterra	Falling Head	6.2×10^{-7}	Red Till
25-1	Waterra	Falling Head	1.4×10^{-4}	Upper Sand?
26-1	Waterra	Falling Head	3.9×10^{-2}	Alluvium?
26-2	Nitrogen	Falling Head	3.2×10^{-4}	Alluvium
27-1	Plastic Bailer	Rising Head	6.7×10^{-6}	Cretaceous Sand
28A-1	Not Attempted	Falling Head	1.0×10^{-8}	Gypsum/Red Till
28B-1	Not Attempted	Falling Head	1.0×10^{-8}	Red Till

NOTE:

* Representative Stratigraphic Horizon is strata judged to control hydraulic conductivity results based on response tests, soil texture, and observations such as drill circulation loss or sand piping.

LIST OF ABBREVIATIONS

The abbreviation commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

Standard Penetration Resistance, *N*:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

WH sampler advanced by static weight — weight, hammer

PH sampler advanced by pressure — pressure, hydraulic

PM sampler advanced by pressure — pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	'N' Blows 0.30m or Blows ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	'Cu' kPa	'Cu' psf.
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer[1]
Q undrained triaxial[2]
R consolidated undrained triaxial[2]
S drained triaxial
U unconfined compression
V field vane test

NOTES

[1]Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
[2]Undrained triaxial tests in which pore pressures are measured are shown as $\bar{Q}$ or $\bar{R}$.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

t time

g acceleration due to gravity

V volume

W weight

M moment

F factor of safety

II. STRESS AND STRAIN

u pore pressure

σ normal stress

σ' normal effective stress ($\bar{\sigma}$ is also used)

τ shear stress

ϵ linear strain

ϵ_{xy} shear strain

ν Poisson's ratio (μ is also used)

E modulus of linear deformation (Young's modulus)

G modulus of shear deformation

K modulus of compressibility

η coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ unit weight of soil (bulk density)

γ_s unit weight of solid particles

γ_w unit weight of water

γ_d unit dry weight of soil (dry density)

γ' unit weight of submerged soil

G_s specific gravity of solid particles $G_s = \gamma_s / \gamma_w$

e void ratio

n porosity

w water content

S_r degree of saturation

(b) *Consistency*

w_L liquid limit

w_P plastic limit

I_P plasticity index

w_s shrinkage limit

I_L liquidity index $= (w - w_P)/I_P$

I_C consistency index $= (w_L - w)/I_P$

e_{max} void ratio in loosest state

e_{min} void ratio in densest state

D_r relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h hydraulic head or potential

q rate of discharge

v velocity of flow

i hydraulic gradient

k coefficient of permeability

j seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$

C_c compression index $= -\Delta e/\Delta \log_{10} \sigma'$

c_v coefficient of consolidation

T_v time factor $= c_v t/d^2$ (d, drainage path)

U degree of consolidation

(e) *Shear strength*

τ_f shear strength

c' effective cohesion intercept

ϕ' effective angle of shearing resistance, or friction

} in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$

c_u apparent cohesion*

ϕ_u apparent angle of shearing resistance, or friction

} in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$

μ coefficient of friction

S_t sensitivity

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

PROJECT: 911-1726

RECORD OF BOREHOLE GA-1A

SHEET 1 OF 2

LOCATION: 7026.479N; 9659.337E

BORING DATE: JULY 10-11,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. ● ○ Q. ● rem V. ● ○ U. ○)	HYDRAULIC CONDUCTIVITY, K, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		518.31 0.00							Water level reference Elev 518.755m; BENTONITE SEAL
		Compact, medium brown SAND, some silt and gravel; dry. (FILL)									
2				516.31 2.00							
		RED TILL									
4		Hard, medium to dark red brown CLAYEY SILT and SAND, some gravel; moist. (TILL)									
6											
8											SILICA SAND
					1	SS	50/DO 47				
10											
12					2	SS	50/DO 46			MH	Piez. 2
14											BENTONITE SEAL
					3	SS	50/DO 50				
16											SILICA SAND
18					4	SS	50/DO 78				
				498.41 18.90							
		LOWER SAND									
20		Compact, brown SAND; wet.									
		CONTINUED ON NEXT PAGE									

0 15 10 5 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: BK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC/RB

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-1A

SHEET 2 OF 2

LOCATION: 7026.479N; 9669.337E

BORING DATE: JULY 10-11,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, K, cm/s	SHEAR STRENGTH Cu, kPa (nat.V. ÷ Q - ●; rem.V. ⊕ U - ○)	WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	CONTINUED FROM PREVIOUS PAGE											
		LOWER SAND CONT'D											
		BEDROCK SURFACE		497.61									
22		White gypsum.		20.70									SILICA SAND; Piez. 1
				495.42									
24		END OF BOREHOLE		22.89									WATER LEVEL IN PIEZ. 1 AT ELEV. 509.74m AND IN PIEZ. 2 AT ELEV. 517.52m ON SEP. 25/91.
		NOTE: Hydrostatic pressure encountered in Lower Sand between 18.9m and 20.7m, resulting in piping of sand into augers.											
26													
28													
30													
32													
34													
36													
38													
40													

0 15 5 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC/RB

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-1B

SHEET 1 OF 1

LOCATION: 7025.329N; 9670.874E

BORING DATE: JULY 4,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		518.35				SHEAR STRENGTH Cu, kPa: nat V · + Q · ● rem V · ⊕ U · ○	WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)		Water level reference Elev. 518.729m
		Compact, medium brown SAND, some silt and gravel; dry. (FILL)		0.00	1	50 DO	20				
2				516.35	2	50 DO	20				BENTONITE SEAL
		RED TILL		2.00							
					3	50 DO	30				SILICA SAND
4		Hard, medium to dark red brown CLAYEY SILT and SAND, some gravel; moist. (TILL)			4	50 DO	29				
					5	50 DO	34				PIEZ. 1
8				510.12	6	50 DO	43				
		END OF BOREHOLE		8.23							WATER LEVEL IN PIEZ. 1 AT ELEV. 517.56m ON SEP. 25/91
10											
12											
14											
16											
18											
20											

DYNAMIC PENETRATION RESISTANCE: 0 / 15 ◆ 5 / 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK OCT 17/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-2

SHEET 1 OF 1

LOCATION: 6441.550N; 9391.719E

BORING DATE: JULY 4-5,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q ●, rem.V. ● U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		519.54							
	HOLLOW STEM AUGERS	COLLUVIUM Soft, medium reddish brown CLAYEY SILT, some sand and gravel; moist.		0.00	1	50 DO	5				Water level reference Elev. 520.037m BENTONITE SEAL
				518.54							
2		UPPER LACUSTRINE CLAY Stiff, medium brown, laminated CLAYEY SILT and SILTY SAND; moist.		1.00	2	50 DO	10				
				516.24	3	50 DO	38				
4	CME 55 POWER AUGER BORING	RED TILL Hard, medium red brown CLAYEY SILT and SAND, some gravel; dry to moist. (TILL)		3.30							SILICA SAND Piez. 2
		Medium brown, wet SILTY SAND layers at 6.3m and 10.7m.			4	50 DO	53				
6	TRI-CONE				5	50 DO	57		○	MH	
											BENTONITE SEAL
8											
											SILICA SAND Piez. 1
10											
				507.96							
12		END OF BOREHOLE		11.58							WATER LEVEL IN PIEZ. 1 AT ELEV. 513.82m AND AT PIEZ. 2 AT ELEV. 518.37m ON SEP. 25/91
		NOTE: Lost drill water circulation at approx. 10.7m depth, possibly in sand layer.									
14											
16											
18											
20								15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: BK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-3

SHEET 1 OF 1

LOCATION: 6697.544N; 9155.741E

BORING DATE: JULY 3,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V +, Q ●, rem V ●, U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		523.74							
		Loose, medium to dark brown, coarse SAND, some silt, trace gravel and wood debris; moist to wet. (FILL)		0.00	1	SS	4				Water level reference Elev 524.459m; BENTONITE SEAL
2					2	SS	7				SILICA SAND; Piez. 2
				520.34	3	SS	18				
4		UPPER LACUSTRINE CLAY Stiff, medium red brown, laminated, interbedded CLAYEY SILT and SILTY SAND; moist to wet.		3.40	4	SS	17				
6					5	SS	11			MH	BENTONITE SEAL
8				515.24	6	SS	-				
		UPPER SAND Compact, medium brown, interbedded, fine to coarse SAND with occasional silt to silty clay layers; moist to wet.		8.50	7	SS	23				SILICA SAND
10					8	SS	12				
12					9	SS	5				Piez. 1
14					10	SS	3				
				508.50							
		END OF BOREHOLE NOTE: Hydrostatic pressure encountered at 15.2m resulting in sand piping into the augers.		15.24							WATER LEVEL IN PIEZ. 1 AT ELEV. 512.56m AND IN PIEZ. 2 AT ELEV. 521.96m ON SEP. 25/91
16											
18											
20											

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa (nat V +, Q ●, rem V ●, U ○)

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT (Wp, W, Wl)

10 20 30 40

0 5 10 15 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: BK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7138.437N; 8441.968E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-4

BORING DATE: JULY 19,1991

SHEET 1 OF 1

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V ⊹, rem V ●, Q ●, U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING, HOLLOW STEM AUGERS	GROUND SURFACE		516.98							
		Stiff, medium red brown CLAYEY SILT, some sand and gravel with occasional fine to medium sand; dry. (FILL)		0.00	1	SS	12				Water level reference Elev. 517.534m. BENTONITE SEAL
				515.48							
2		UPPER SAND		1.50							
		Compact, light to medium brown to greyish brown, interbedded fine to coarse SAND, occasional gravel layers; moist, becoming wet below 9.0m.			2	SS	13				
4											
6					3	SS	31				
8											SILICA SAND
					4	SS	21				
10											
12					5	SS	9				
14											
					6	SS	27				
16											Piez. 1
		BEDROCK SURFACE		499.28							
18	TRI-CONE	Grey CARBONATE.		17.70							
				497.15							
20		END OF BOREHOLE		19.81							PIEZ. 1 DRY AT ELEV. 497.48m ON SEP. 25/91.

0 / 5 / 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: BK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: LG

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-5

SHEET 1 OF 3

LOCATION: 7017.353N; 8321.728E

BORING DATE: JULY 18-21,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q ●, rem.V. ⊕ U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		534.86							
		UPPER SAND		0.00							Water level reference Elev 535.404m
2	TRI-CONE	Medium brown SILTY SAND and SAND, some gravel.									BENTONITE SEAL
4		NOTE: Very poor definition of soil stratigraphy due to condition of wash samples returned to surface during tricone drilling.			1	WS					
6					2	WS					
8	LONGYEAR 38 - ROTARY DRILLING N TRI-CONE / N CASING										
10					3	WS					SILICA SAND
12											
14					4	WS					
16					5	WS					
18					6	WS					
20		CONTINUED ON NEXT PAGE									

DATA INPUT: SK OCT 12/91

DYNAMIC PENETRATION RESISTANCE: 5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-5

SHEET 2 OF 3

LOCATION: 7017.353N; 8321.726E

BORING DATE: JULY 18-21,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q. ● / rem.V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	LONGYEAR 38 - ROTARY DRILLING N TRI-CONE / N CASING	CONTINUED FROM PREVIOUS PAGE									
		UPPER SAND CONT'D			6	WS					
22		Medium brown SILTY SAND and SAND, some gravel.			7	WS					
24											
26					8	WS					
28					9	WS					
30											SILICA SAND
32					10	WS					
34											
36					11	WS					
38					12	WS					Piez. 1
		BEDROCK SURFACE		495.19							
40		White GYPSUM.		39.67	13	WS					
		CONTINUED ON NEXT PAGE									

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-5

SHEET 3 OF 3

LOCATION: 7017.353N; 8321.728E

BORING DATE: JULY 18-21,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
40	LONGYEAR 38 N TRI-CONE	CONTINUED FROM PREVIOUS PAGE						SHEAR STRENGTH Cu, kPa: nat V - + Q - ● rem V - ● U - ○	WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)		
42		White GYPSUM.		492.19	13	WS					
				42.67							
44		END OF BOREHOLE NOTE: Matex was used in drill water to maintain circulation throughout drilling.									WATER LEVEL IN PIEZ. 1 AT ELEV. 495.78m ON SEP. 25/91
46											
48											
50											
52											
54											
56											
58											
60											

0 5 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: BK OCT. 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 6973.085N; 8149.895E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-6

BORING DATE: AUG. 1-6,1991

SHEET 1 OF 3

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		539.75 / 0.00				SHEAR STRENGTH Cu, kPa: nat.V. + Q. ● ; rem.V. ⊕ U. ○	WATER CONTENT, PERCENT: Wp, W, Wl (10, 20, 30, 40)		
	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	RED TILL			1	SS	6				Water level reference Elev 540.232m. BENTONITE SEAL
2		Very stiff to hard, medium red brown CLAYEY SILT and SAND, some gravel; moist. (TILL)			2	SS	10				
					3	SS	19				
4					4	SS	18				
6		Becomes dark red-brown, massive textured till below 6.0m.									
					5	SS	24				
8											
10											SILICA SAND
					6	SS	> 50				
12											
					7	SS	57				
14											
16											
					8	SS	32				
18											
20		CONTINUED ON NEXT PAGE			9	SS	50/0.15			MH	

0 / 5 / 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: JM

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-6

SHEET 2 OF 3

LOCATION: 6973.085N; 8149.895E

BORING DATE: AUG. 1-6,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. ⊕ Q ●; rem V. ● U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	CONTINUED FROM PREVIOUS PAGE									
		RED TILL CONT'D			9	50 00	48			MH	
22											
24											
26					10	50 00	R				
28				511.75							
		LOWER SAND 28.00 Compact, medium grey-brown, fine to medium SAND, some silt and gravel. Contains pellets of grey clay.			11	50 00	R			MH	Piez. 2
30				509.55							
		LOWER LACUSTRINE CLAY 30.20 Hard, dark brown, finely laminated SILTY CLAY grading down to CLAYEY SILT, cohesive, plastic, with brown silty sand; moist, laminated.									
32					12	50 00	82			MH	
34											BENTONITE SEAL
36					13	50 00	73				
38				501.75							SILICA SAND
		LOWER TILL 38.00 Hard, dark grey-brown CLAYEY SILT and SAND, trace to some gravel, massive textured to faintly laminated.									
40					14	50 00	R			MH	
		CONTINUED ON NEXT PAGE									

DATA INPUT: BK NOV 12/91

5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: JM

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-6

SHEET 3 OF 3

LOCATION: 6973.085N; 8149.895E

BORING DATE: AUG. 1-6,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

FENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. + Q - ●, rem V. ● U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
40		CONTINUED FROM PREVIOUS PAGE									
	HOLLOW STEM AUGERS / CME 55 POWER AUGER BORING	LOWER TILL CONT'D									
42		Gravel clasts are polymictic mixture of quartz, quartzite, red and grey sandstone, granite and quartz-pyrite.			15	SS DO	R		o — I	MH	SILICA SAND
44											
46											
48		BEDROCK SURFACE		491.60							
				48.15							
50											
52	N TRI-CONE	White GYPSUM.									Piez. 1
54											
				484.58							
56		END OF BOREHOLE		55.17							WATER LEVEL IN PIEZ. 1 AT ELEV. 501.88m AND IN PIEZ. 2 AT ELEV. 510.77m ON SEP. 25/91.
58											
60								0 / 25 ◆ 5 / 10 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: SK NOV 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: JM

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-7

SHEET 1 OF 2

LOCATION: 6774.648N; 7758.687E

BORING DATE: AUG. 10-12,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V ·+ Q ·● rem V ·● U ·○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		534.78							
		RED TILL		0.00							Water level reference Elev. 535.38m; BENTONITE SEAL
2		Very stiff to hard, medium red brown CLAYEY SILT and SAND, trace to some gravel; moist. (TILL)			1	SS	19				
					2	SS	20				
4					3	SS	19				
6					4	SS	25				
8											
					5	SS	26				
10											SILICA SAND
12					6	SS	40				
		Becomes dark reddish brown, massive textured till below approximately 13.0m.									
14											
					7	SS	67				
16											
18											
					8	SS	65				
20		CONTINUED ON NEXT PAGE									

DATA INPUT: BK OCT 12/91

DYNAMIC PENETRATION RESISTANCE: 0 5 10 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-7

SHEET 2 OF 2

LOCATION: 6774.648N; 7758.687E

BORING DATE: AUG. 10-12,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	HOLLOW STEM AUGERING	CONTINUED FROM PREVIOUS PAGE						SHEAR STRENGTH Cu, kPa: nat V. + Q. ● ; rem V. ● U. ○	WATER CONTENT, PERCENT: Wp, W, Wl (10, 20, 30, 40)		
		RED TILL CONT'D			9	SS	91				
22		BEDROCK SURFACE		512.51							
				22.25							SILICA SAND
24											
26	CME-55 POWER AUGER BORING N TRI-CONE	White GYPSUM.									
28											
30											Piez. 1
32											
34											
36				476.16							
		END OF BOREHOLE		36.58							WATER LEVEL IN PIEZ. 1 AT ELEV. 511.56m ON SEP. 25/91.
38		NOTE: Lost drill water circulation at 22.25m at bedrock surface.									
40								0 / 5 / 10 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT BK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-8A

SHEET 1 OF 1

LOCATION: 6503.915N; 7242.850E

BORING DATE: JULY 31,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	HOLLOW STEM AUGERS	GROUND SURFACE		513.97				SHEAR STRENGTH Cu, kPa: nat V - + Q - ● rem V - ● U - ○	WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)		
		RIVER ALLUVIUM		0.00							Water level reference Elev. 514.502m.
2		Firm to loose, dark brown CLAYEY SAND and SILT, some gravel.			1	SS	7				BENTONITE SEAL
					2	SS	7				
4		BEDROCK SURFACE		509.70							
	CME-55 POWER AUGER BORING			4.27							
6		White GYPSUM.									
	TRI-CONE	NOTE: Drill water circulation was lost in fracture at 6.7m.		507.27 6.70							SILICA SAND
8											
10											Piez. 1
12		END OF BOREHOLE		501.78 12.19							WATER LEVEL IN PIEZ. 1 AT ELEV. 511.68m ON SEP. 25/91.
14											
16											
18											
20								0 5 10 5 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-8B

SHEET 1 OF 1

LOCATION: 6505.985N; 7242.513E

BORING DATE: JULY 31,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q. ●; rem.V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER BORING; SOLID STEM AUGERS	GROUND SURFACE		513.99							
		RIVER ALLUVIUM Firm to loose, dark brown CLAYEY SAND and SILT, some gravel.		0.00							Water level reference Elev. 514.687m. BENTONITE SEAL Piez. 1 SILICA SAND
2				510.39							
		END OF BOREHOLE		3.60							WATER LEVEL IN PIEZ. 1 AT ELEV. 512.80m ON SEP. 25/91
4											
6											
8											
10											
12											
14											
16											
18											
20											

DATA INPUT SK OCT 12/91

PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE 9A

SHEET 1 OF 2

LOCATION: 7035.667N; 7741.694E

BORING DATE: JULY 29-30,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q. ● / rem.V. ● U. ○)	HYDRAULIC CONDUCTIVITY k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERING	GROUND SURFACE		519.86							
		UPPER SAND		0.00							Water level reference Elev. 519.541m.
2		Compact to very dense, red brown, interbedded SILTY SAND and fine to medium SAND, occasional thin layers of clayey silt and gravelly sand; dry to moist, becoming wet below 9.0m.			1	SS	8		○	MH	BENTONITE SEAL
4					2	SS	7				
6					3	SS	8		○	MH	
					4	SS	12				
8											SILICA SAND
10		Becomes predominantly fine to coarse SAND, trace to some gravel and silty sand and gravel below 10.0m.			5	SS	44				
12					6	SS	R				
14											
16					7	SS	R				
				502.36							
		CRETACEOUS CLAY Hard, dark grey CLAYEY SILT and SAND, some gravel, slightly plastic; moist.		16.50							
18		BEDROCK SURFACE		500.36	8	SS	R				
	IN TRI-CONE			18.50							
20		White GYPSUM.									
		CONTINUED ON NEXT PAGE									

DATA INPUT: BK OCT 1991

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7035.667N; 7741.694E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 9A

BORING DATE: JULY 29-30,1991

SHEET 2 OF 2

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q. ● rem.V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME-55 POWER AUGER BORING; N TRI-CONE	CONTINUED FROM PREVIOUS PAGE									
		GYPSUM CONT'D									SILICA SAND
		NOTE: Void encountered between 21.0m and 21.3m where drill water circulation was lost. Drill water circulation returned at 23.0m (50%).		497.86 21.00 21.30							Piez. 1
24				492.95 25.91							
26		END OF BOREHOLE									WATER LEVEL IN PIEZ. 1 AT ELEV. 507.90m ON SEP. 25/91
28											
30											
32											
34											
36											
38											
40											

DATA INPUT BY: DCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7036.534N; 7743.014E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-9B

BORING DATE: AUG. 12-13,1991

SHEET 1 OF 1

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		519.16							
		UPPER SAND		0.00							
2		Compact to very dense, red brown, interbedded SILTY SAND and fine to medium SAND, occasional thin layers of clayey silt and gravelly sand; dry to moist, becomes wet below 9.0m.			1	SS DO	10				
4											
6					2	SS DO	9				
8											SILICA SAND
					3	SS DO	38				
10		Becomes predominantly fine to coarse SAND, trace to some gravel and silty sand and gravel below 10.0m.									PIEZ. 2
12		NOTE: - Piping sand encountered at 12.2m.			4	SS DO	50/ 10				
14											BENTONITE SEAL
		- Lost drill water circulation between 15.0m to 17.5m in permeable sand and gravel.			5	SS DO	48				
16											SILICA SAND
				501.66							PIEZ. 1
18		CRETACEOUS CLAY Hard, dark grey CLAYEY SILT and SAND, some gravel, slightly plastic; moist.		17.50	6	SS DO	82				
				500.42							
20		END OF BOREHOLE		18.74							

Water level reference Elev 519.440m

WATER LEVEL IN PIEZ. 2 AT ELEV. 508.94m ON SEP. 25/91.
PIEZ. 1 RISER PIPE BROKEN AT DEPTH OF 12.2m.
PIEZ. 1 DRY AT 508.49m.

0 / 15 / 10 5 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: BK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-10A

SHEET 1 OF 3

LOCATION: 7223.849N; 7996.876E

BORING DATE: JULY 26-28,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q. ● / rem.V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		516.17							
		UPPER SAND Loose to compact, medium brown, fine to medium SAND, trace silt, occasional silty sand and coarse sand and gravel layers; moist, becoming wet below 4.0m.		0.00	1	SS	11				Water level reference Elev. 516.761m. BENTONITE SEAL
2					2	SS	2				
4				512.17 4.00	3	SS	10			MH	
6					4	SS	7				
				508.67 7.50	5	SS	11				SILICA SAND
8					6	SS	17				
10					7	SS	9			MH	
12					8	SS	17				
		Below 13.0m becomes compact to dense, medium brown, interbedded SILTY SAND and CLAYEY SILT, trace gravel; wet.		503.17 13.00	9	SS	24				
14					10	SS	24				
16					11	SS	62				
		CRETACEOUS CLAY Hard, light to dark grey, laminated to massive textured SILTY CLAY to CLAYEY SILT and SAND, trace gravel, trace black carbon (wood); moist. Gravel clasts are quartz, quartzite, sandstone, carbonate and gypsum.		498.67 17.50							BENTONITE SEAL
18											
20					12	SS	70			MH	
		CONTINUED ON NEXT PAGE						5 10 15 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: SK OCT. 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7223.849N; 7996.876E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-10A

BORING DATE: JULY 26-28,1991

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DATUM: MINE

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ●, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	CONTINUED FROM PREVIOUS PAGE									
		CRETACOUS CLAY CONT'D									
22		Gypsum clasts tend to be weathered to fine grained, light grey granular material.			13	SS DO	33/ 08				
24											
				490.67 25.50							
26		NOTE: Lost drill water circulation between 25.5m and 28.5m and again between 38.0m and 39.5m probably in permeable sands and gravels interbedded within the trench clay. (See Geophysical Record of Borehole GA-10A)									
28				487.67 28.50	14	SS DO	R				
30											SILICA SAND
32					15	SS DO	R				
34											
36											
38				478.17 38.00	16	SS DO	R			MH	
				478.67 38.50							
40		CONTINUED ON NEXT PAGE									

DATA INPUT: BK OCT 12/91

DYNAMIC PENETRATION RESISTANCE: 5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-10A

SHEET 3 OF 3

LOCATION: 7223.649N; 7996.876E

BORING DATE: JULY 26-28,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
40	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS; N TRI-CONE	CONTINUED FROM PREVIOUS PAGE						SHEAR STRENGTH Cu, kPa; nat.V. + Q ●; rem.V. ● U ○	WATER CONTENT, PERCENT; Wp 10 20 30 40 Wl; W		
42		CRETACEOUS CLAY (cont'd)									
		BEDROCK SURFACE		474.17							
				42.00							SILICA SAND
44		White GYPSUM.									PIEZ. 1
		NOTE: Partial drill water circulation loss in bedrock.									
46				469.23							
		END OF BOREHOLE		48.94							WATER LEVEL IN PIEZ. 1 AT ELEV. 507.11m ON SEP. 25/91.
48											
50											
52											
54											
56											
58											
60								0 5 10 5 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-10B

SHEET 1 OF 1

LOCATION: 7222.533N; 7997.654E

BORING DATE: JULY 26-28,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V - ⊕, rem V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		516.35							
		UPPER SAND Loose to compact, medium brown, fine to medium SAND, trace silt, occasional silty sand and coarse sand and gravel layers; moist, becoming wet below 4.0m.		0.00							Water level reference Elev. 516.978m. BENTONITE SEAL
2											
4				512.35 4.00							
6											SILICA SAND
8				508.85 7.50							
10											PIEZ. 1
		END OF BOREHOLE		505.65 10.70							WATER LEVEL IN PIEZ. 1 AT ELEV. 511.53m ON SEP. 25/91.
12											
14											
16											
18											
20											

DATA INPUT: BK OCT. 12/91

DYNAMIC PENETRATION: 15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE 10

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-11

SHEET 1 OF 1

LOCATION: 7525.332N; 8700.969E

BORING DATE: JULY 8,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V.- + Q-● rem.V.- ● U-○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		515.52							
		UPPER LACUSTRINE CLAY Firm, dark red brown, laminated CLAYEY SILT with minor fine sand laminations; moist to wet.		0.00	1	SS	8				Water level reference Elev. 516.064m BENTONITE SEAL
2					2	SS	6				
					3	SS	5				SILICA SAND Piez. 3
4				511.52							
		UPPER SAND Loose, medium brown, dilatent, layered SILT and fine SAND with occasional clay laminations; wet.		4.00	4	SS	7				BENTONITE SEAL
6					5	SS	5				
					6	SS	7				SILICA SAND Piez. 2 DRY
8				507.02							
		RED TILL Hard, medium red brown CLAYEY SILT and SAND, some gravel; moist. (TILL) Grading downward to SANDY SILT, some gravel, trace clay (TILL) in lower half.		8.50	7	SS	33				BENTONITE SEAL
10					8	SS	>50				
12		BEDROCK SURFACE		503.32		SS	>50				SILICA SAND Piez. 1
	IN TRI-CONE	White GYPSUM.		12.20							
14											
				500.28	10	AS					
16		**END OF BOREHOLE** NOTE: Retained drill water circulation in bedrock.		15.24							PIEZ. 2 DRY AT ELEV. 507.02m. WATER LEVEL IN PIEZ. 1 AT ELEV. 503.57 AND IN PIEZ 3 AT ELEV. 513.31m ON SEP. 25/91.
18											
20											

DATA INPUT: BK OCT 17/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7517.021N; 9051.131E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-12

BORING DATE: JULY 6-7,1991

SHEET 1 OF 2

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. +, Q ●; rem V. ●, U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		515.22							Water level reference Elev. 515.801m
		ROAD FILL Light brown SAND and GRAVEL, some silt		0.00 514.62	1	SS	7				
		PEAT Dark brown, fibrous PEAT and ORGANIC SOIL		0.60 513.42	2	SS	1				
2		UPPER LACUSTRINE CLAY Stiff, dark red brown, laminated CLAYEY SILT; moist to wet.		1.80	3	SS	15			MH	SILICA SAND
				511.22							Piez. 2
4		UPPER SAND Loose, medium brown SAND and GRAVEL, some silt.		4.00	4	SS	9				
				509.21							
6		RED TILL Hard, medium red brown CLAYEY SILT and SAND, some gravel; moist. (TILL)		6.01	5	SS	54				BENTONITE SEAL
8											
10					6	SS	> 50				
12					7	SS	114			MH	
				501.22							SILICA SAND
14		LOWER LACUSTRINE CLAY Hard, dark red brown, laminated SILTY CLAY with occasional gravel dropstones and very thin to laminated layers of silt and fine sand; moist to wet.		14.00							
16					8	SS	55			MH	
18				496.92							
		LOWER SAND Very dense, medium brown SILTY SAND grading down to coarse SAND with occasional laminations of silt and clay.		18.30	9	SS	77				
20		CONTINUED ON NEXT PAGE									

DATA INPUT: BK OCT 12/91

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7517.021N; 9051.131E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-12

BORING DATE: JULY 6-7,1991

SHEET 2 OF 2

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. + Q. ●; rem V. ⊕ U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	CONTINUED FROM PREVIOUS PAGE									
		LOWER SAND CONT'D									SILICA SAND
22				492.51	10	SS	123		○	MH	Piez. 1
		END OF BOREHOLE		22.71							WATER LEVEL IN PIEZ. 1 AT ELEV. 501.64m AND IN PIEZ. 2 AT ELEV. 514.68m ON SEP. 25/91
24		NOTE: Borehole terminated in Lower Sand.									
26											
28											
30											
32											
34											
36											
38											
40											

DATA INPUT: BK OCT 12/91

15 (5 PERCENT AXIAL STRAIN AT FAILURE)

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-13

SHEET 1 OF 4

LOCATION: 7267.508N; 9153.832E

BORING DATE: JULY 24-31,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q. ●; rem.V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	LONGYEAR 38 TRI-CONE	GROUND SURFACE		525.25 0.00							Water level reference Elev. 525.971m
		Brown SILTY SAND. (FILL)		523.75 1.50							
2		RED TILL									
		Hard, medium red brown CLAYEY SILT and SAND, some gravel; moist. (TILL)			1	SS	PH				
4											
6					2	SS	PH				
8											SILICA SAND
					3	SS	PH				
10				514.58 10.67							
		LOWER SAND									
12		Dense, grey to brown SILTY fine SAND to SILTY coarse SAND and GRAVEL with occasional cobbles.			4	SS	PH				
14											
					5	SS	PH				
16											
18											
					6	SS	PH				
20		CONTINUED ON NEXT PAGE						0 5 10 % PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: BK OCT 17/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7287.508N; 9153.832E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-13

BORING DATE: JULY 24-31,1991

SHEET 2 OF 4

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. + Q. ●; rem V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		CONTINUED FROM PREVIOUS PAGE									
		LOWER SAND CONT'D									BENTONITE SEAL
22		Dense, grey to brown SILTY fine SAND to SILTY coarse SAND and GRAVEL, occasional cobbles.									
24					7	SS	PH				
26					8	SS	PH				
28		TRI-CONE									
30		LONGYEAR 38			9	SS	PH				SILICA SAND
32											
34					10	SS	PH				
36					11	RC	-				
		BEDROCK SURFACE		488.08							
38		White GYPSUM		37.19	12	RC	-				
		BQ CORING		485.93	13	RC	-				
40				39.32	14	RC	-				
		CONTINUED ON NEXT PAGE									

DATA INPUT: BK OCT 17/91

ε1 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-13

SHEET 3 OF 4

LOCATION: 7267.508N; 9153.832E

BORING DATE: JULY 24-31,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q. ● rem.V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
40	LONGYEAR 38 BQ CORING	CONTINUED FROM PREVIOUS PAGE			14	RC					
		Bedrock cavity infilled with SILT, SAND and GRAVEL			15	RC					
42					16	RC					
				482.12	17	RC					
		White GYPSUM		43.13							
				481.38							
44				43.89	18	RC					
		Bedrock cavity infilled with SILT, SAND and GRAVEL			19	RC					
46		NOTE: Gravel infill comprised of subangular to subrounded pebbles and cobbles of granite, volcanics, carbonate, quartzite and gypsum in all infilled cavities/zones.			20	RC					
					21	RC					
48					22	RC					
				476.48							
		White GYPSUM		48.77	23	RC					SILICA SAND
50				474.04							
				51.21							
52		Bedrock cavity infilled with SILT, SAND and GRAVEL			24	RC					
					25	RC					Piez. 1
54											
				468.56	26	RC					
		OPEN VOID (Drill rods dropped)		56.69							
56				467.95							
		SILT, SAND and GRAVEL		57.30							
				467.34							
58		White GYPSUM		57.91	27	RC					
60		CONTINUED ON NEXT PAGE									

DATA INPUT: BK OCT 17/91

DYNAMIC PENETRATION RESISTANCE: ◆ 5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7287.508N; 9153.832E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-13

BORING DATE: JULY 24-31,1991

SHEET 4 OF 4

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
60	LONGYEAR 38 (BQ) CORING	CONTINUED FROM PREVIOUS PAGE						SHEAR STRENGTH Cu, kPa: nat.V - + Q - ● rem.V - ● U - ○	WATER CONTENT, PERCENT: Wp, W, Wl (10, 20, 30, 40)		
		White GYPSUM		484.29	27	RC					
		SILT, SAND and GRAVEL		60.96 463.68	28	RC					
62		Grey CARBONATE		61.57	29	RC					
				462.10							
		END OF BOREHOLE		63.09							
64											
66											
68											
70											
72											
74											
76											
78											
80											

NOTE:
- Matex was used in drill water to maintain circulation throughout drilling.
- Piezometer screen interval is directly connected to underground workings noted by faint flow of air issuing from open piezometer following completion of installation and subsequent monitoring.

WATER LEVEL IN PIEZ. 1 AT ELEV. 484.07m ON SEP. 25/91

25 - 5 PERCENT AXIAL STRAIN AT FAILURE - 10

DATA INPUT: SK OCT. 17/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-14A

SHEET 1 OF 2

LOCATION: 7299.490N; 8348.537E

BORING DATE: JULY 24-25,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q. ●, rem.V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		514.00							
		ALLUVIUM Soft, grey CLAYEY SILT; moist.		0.00 513.00	1	SS	3				Water level reference Elev. 514.461m.
		UPPER SAND		1.00							BENTONITE SEAL
2		Loose, light grey to brown, fine to coarse SAND, trace silt with interbedded layers of silt and clayey silt; wet.			2	SS	3				
					3	SS	3			MH	SILICA SAND
4					4	SS	3				
6					5	SS	4			MH	
				509.10	6	SS	10				
8	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	RED TILL Hard, medium red brown CLAYEY SILT and SAND, trace to some gravel. (TILL)		7.90	7	SS	64			MH	BENTONITE SEAL
10											
12					8	SS	R				SILICA SAND
		LOWER SAND Very dense, medium brown, fine to coarse SAND, some silt. 0.5m of very dense, brown, massive textured SANDY SILT, some gravel overlying bedrock. NOTE: Sand piped into augers.		500.00 14.00							
14					9	SS	R				
		BEDROCK SURFACE		498.20 15.80							
16	IN TRI-CONE	White GYPSUM									Piez. 1
18											
20		CONTINUED ON NEXT PAGE									

DATA INPUT BY: OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: RB

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7299.490N; 8348.537E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-14A

BORING DATE: JULY 24-25,1991

SHEET 2 OF 2

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME-55 POWER AUGER BORING & TRI-CONE	CONTINUED FROM PREVIOUS PAGE						SHEAR STRENGTH Cu, kPa: nat.V. + Q. ● rem.V. ● U. ○	WATER CONTENT, PERCENT Wp, W, Wl (10, 20, 30, 40)		
22		White GYPSUM		492.00 21.95							
		END OF BOREHOLE									WATER LEVEL IN PIEZ. 1 AT ELEV. 488.52m ON SEP. 25/91
24		NOTE: Maintained drill water circulation throughout bedrock.									
26											
28											
30											
32											
34											
36											
38											
40											

15.4 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: BA OCT 10/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: RB

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-14B

SHEET 1 OF 1

LOCATION: 7300.582N; 8347.555E

BORING DATE: JULY 24-25,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. +, Q. ●, rem V. ●, U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		514.03							
		ALLUVIUM Soft, grey CLAYEY SILT, moist.		0.00 513.03							
2		UPPER SAND Loose, light grey to brown, fine to coarse SAND, trace silt with interbedded layers of silt and clayey silt; wet.		1.00							
4											SILICA SAND
6				506.13							Piez. 1
8		RED TILL Hard, medium red brown CLAYEY SILT and SAND, trace to some gravel. (TILL)		7.90 504.83							
		END OF BOREHOLE		9.20							WATER LEVEL IN PIEZ. 1 AT ELEV. 508.94m ON SEP. 25/91
10											
12											
14											
16											
18											
20											

Water level reference Elev. 514.533m

BENTONITE SEAL

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 0 / 15 / 10

5 PERCENT AXIAL STRAIN AT FAILURE

WATER CONTENT, PERCENT: Wp 15 | W 20 | 30 | Wl 40

DATA INPUT: SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: RB

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-15

SHEET 1 OF 3

LOCATION: 7255.881n; 6721.772E

BORING DATE: JULY 11-16,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. ⊹ Q ● / rem.V. ● U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, WI; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		518.56							
		ORGANIC SOIL and ROOTS.		0.00 518.16	1	SS	6				Water level reference Elev. 518.908m.
		UPPER LACUSTRINE CLAY Firm, medium brown to grey brown, interbedded SILTY SAND and laminated CLAYEY SILT; moist becoming wet below 7.5m.		0.40	2	SS	6				BENTONITE SEAL
2					3	SS	6				
4					4	SS	5				
6					5	SS	4			MH	
8					6	SS	-				Piez. 3
				510.06							
		UPPER SAND Compact to dense, interlayered fine to coarse SAND, trace to some silt, occasional interlaminations of clayey silt; wet.		8.50	7	SS	12				
10					8	SS	11				SILICA SAND
12					9	SS	37			MH	
				504.56							
14		RED TILL Hard, medium red brown CLAYEY SILT and SAND, some gravel. (TILL)		14.00	10	SS	R				
16											
18	TRI-CONE / N CASING				11	SS	> 50			MH	
20		CONTINUED ON NEXT PAGE									

S ◆ 5 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: BK OCT 17/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-15

SHEET 2 OF 3

LOCATION: 7255.881n; 8721.772E

BORING DATE: JULY 11-16,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q ●; rem.V. ● U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		CONTINUED FROM PREVIOUS PAGE									
		RED TILL CONT'D			12	SS	> 50				
22				495.58 23.00							
		CRETACEOUS CLAY Hard, light to dark grey, massive to laminated bedding, CLAYEY SILT and SAND, trace to some gravel; moist.			13	SS	R				BENTONITE SEAL
24											
26				491.08 27.50	14	SS	75			MH	
28	CME 55 POWER AUGER BORING & TRI-CONE / H CASING	CRETACEOUS SAND Dense, light grey, siliceous, fine to medium SAND; wet. NOTE: Sand piped into casing.			15 16	AS WS					SILICA SAND
30					17	WS					
32					18	WS					Pez. 2
34					19	WS					DRY
36				491.98 36.58	20	SS	> 50				
		CRETACEOUS CLAY (CONT'D) Hard, light to dark grey, massive to laminated bedded CLAYEY SILT and SAND, trace gravel; moist.									BENTONITE SEAL
38					21	SS	R			MH	
40		CONTINUED ON NEXT PAGE									

DATA INPUT: BA OCT 17/91

DYNAMIC PENETRATION RESISTANCE: 5 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE
1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7255.881n; 8721.772E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-15

BORING DATE: JULY 11-18,1991

SHEET 3 OF 3

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + ○·● rem.V. ● U·○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
40	CME-55 POWER AUGER BORING; N TRI-CONE / HI CASING	CONTINUED FROM PREVIOUS PAGE									
		CRETACEOUS CLAY CONT'D Hard, light to dark grey, massive to laminated bedded CLAYEY SILT and SAND, trace gravel, trace black carbon (wood); moist.									
42					10	SS	90/ 60				
		NOTE: Majority of gravel clasts were irregular shaped iron sulphide.									
44											
46					11	SS	90/ 10				SILICA SAND
48											
					21	SS	90/ 13		○	MH	
50											
52											Piez. 1
54				483.70							
		END OF BOREHOLE		54.68							PIEZ. 2 DRY AT ELEV. 482.60m. WATER LEVEL IN PIEZ. 1 AT ELEV. 481.19m AND IN PIEZ. 3 AT ELEV. 510.77m ON SEP. 25/91.
56											
58											
60								15 ● 5 PERCENT AXIAL STRAIN AT FAILURE 10			

DATA INPUT: BK OCT 17/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-16

SHEET 1 OF 2

LOCATION: 7099.000N; 8535.434E

BORING DATE: JULY 16-17,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		519.23 / 0.00				SHEAR STRENGTH Cu, kPa: nat V. ⊕ Q. ● rem V. ● U. ○	WATER CONTENT, PERCENT: Wp, W, Wl (10, 20, 30, 40)		Water level reference Elev 519.982m
		UPPER SAND			1	SS	11				BENTONITE SEAL
		Loose to compact, medium brown SAND and SANDY SILT, trace gravel, occasional thin silt and clayey silt layers; moist.			2	SS	7				
					3	SS	9				
					4	SS	18				SILICA SAND
					5	SS	28				
					6	SS	26				
		BEDROCK SURFACE		501.83 / 17.40							Piez. 1
	IN TRI-CONE	Grey, fractured CARBONATE									
		NOTE: Lost drill water circulation in bedrock.									
		CONTINUED ON NEXT PAGE									

S ◆ S PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: BK OCT 1991

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-16

SHEET 2 OF 2

LOCATION: 7099.000N; 8535.434E

BORING DATE: JULY 16-17,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. ✣ Q. ⊕; rem V. ⊕ U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME-55 POWER AUGER; NTW-CORE	CONTINUED FROM PREVIOUS PAGE									
				486.81							
		END OF BOREHOLE		20.42							WATER LEVEL IN PIEZ. 1 AT ELEV. 500.65m ON SEP. 25/91
22											
24											
26											
28											
30											
32											
34											
36											
38											
40											

DATA INPUT: BK OCT 12/91

S = PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-17

SHEET 1 OF 4

LOCATION: 6572.390N; 7677.688E

BORING DATE: AUG. 1-6,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. ✧ Q ● / rem.V. ● U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	LOWYEAR 38 mm TRI-CONE / later CASING	GROUND SURFACE		532.37							Water level reference Elev. 532.641m
		RED TILL Hard, medium red brown CLAYEY SILT and SAND, some gravel; moist. (TILL)		0.00	1	SS	PH				SILICA SAND
4					2	SS	PH				BENTONITE SEAL
8					3	SS	PH		D	MH	
12					4	SS	PH				SILICA SAND
14		Becomes dark reddish brown, massive CLAYEY SILT and SAND below 15m.			5	SS	PH				
16		LOWER SAND Dense medium brown SILTY SAND with occasional thin clayey silt layers and laminations.		514.37 18.00							
20		CONTINUED ON NEXT PAGE						15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 6572.390N; 7677.668E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-17

BORING DATE: AUG. 1-6,1991

SHEET 2 OF 4

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V - ⊕ Q - ●; rem V - ● U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	LOADYEAR 38 N TRI-CONE / HW CASING	CONTINUED FROM PREVIOUS PAGE									
		LOWER SAND CONT'D			6	SS	00 PH				
22											
24					7	SS	00 PH			MH	
26		NOTE: Lost drill water circulation at 18.9m and regained circulation with addition of REVERT drill water addative.									
28					8	SS	00 PH				
30		LOWER TILL		302.37 / 30.00	9	SS	00 PH				SILICA SAND
32		Hard, light grey brown, massive textured to faintly laminated CLAYEY SILT and SAND, some gravel; moist. (TILL) Gravel clasts consist of subangular to subrounded pebbles of felsic to mafic volcanic, quartzite, granite, carbonate and gypsum.									
34					10	SS	00 PH				
36											
38	BQ CORING				11	RC	PH				
					12	RC	PH				
40		CONTINUED ON NEXT PAGE			13	SS	00 PH				

S PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-17

SHEET 3 OF 4

LOCATION: 6572.390N; 7677.688E

BORING DATE: AUG. 1-6,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH C_u, kPa (nat V. ✣ C. ●, rem V. ● U. ○)	HYDRAULIC CONDUCTIVITY, K, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
40	LONGYEAR 38 BQ CORING	CONTINUED FROM PREVIOUS PAGE									
		LOWER TILL CONT'D			13	SS	PH				
42											
					14	SS	PH				
44											
					15	SS	PH				
46											
		BEDROCK SURFACE		463.37							
48				46.00							
		White GYPSUM			16	RC	-				SILICA SAND
50				460.55							
				51.82	17	SS	-				
52		Bedrock cavity infilled with light to medium brown SILTY SAND, some gravel. Gravel clasts consist of quartzite, sandstone, carbonate and granite.									
54											
56					18	SS	PH				
				474.48							
				57.91							
58		White GYPSUM			19	RC	-				
				472.93							
				59.44	20	RC	-				
60		CONTINUED ON NEXT PAGE									

DATA INPUT: BR, OCT 10/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-17

SHEET 4 OF 4

LOCATION: 6572.380N; 7677.588E

BORING DATE: AUG. 1-8,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. ✣ Q. ●; rem V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
60	LONGYEAR 38 RD CORING	CONTINUED FROM PREVIOUS PAGE									
62		Bedrock cavity infilled with light brown CLAYEY SILT and SAND, some gravel. Gravel clasts comprised of quartzite, sandstone, carbonate, gypsum and granite.			20	RC					
64					21	RC					
66					22	RC					
68				484.70 67.67	23	RC					
70		Grey CARBONATE and massive to disseminated sphalerite mineralization.			24	RC					Piez. 1
72				459.22 73.15							
74		END OF BOREHOLE NOTE: Maintained drill water circulation with Revert. Hole flushed with chlorine bleach on completion.									WATER LEVEL IN PIEZ. 1 AT ELEV. 483.38m ON SEP 25/91
76											
78											
80											

0.4 & 5 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK OCT 10/91

DEPTH SCALE
1 to 100

Golder Associates

LOGGED: AJC
CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-18

SHEET 1 OF 2

LOCATION: 7780.544N; 9273.828E

BORING DATE: JULY 9,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. + Q. ●, rem V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		317.77							
		ORGANICS		317.57 / 0.20	1	SS	8				Water level reference Elev. 318.121m; BENTONITE SEAL
	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	RED TILL Hard, medium to red brown CLAYEY SILT and SAND, some gravel; moist. (TILL)			2	SS	25				
4					3	SS	33				SILICA SAND
					4	SS	33				
8											Piez. 2
					5	SS	8				
											BENTONITE SEAL
12				304.77 / 13.00	6	SS	64				
		LOWER SAND Very dense, light grey to grey brown, interbedded SILTY SAND and medium to coarse SAND, some gravel to gravelly, trace silt; wet.			7	SS	> 50				
16											SILICA SAND
					8	SS	> 50		D	MH	
20		NOTE: Sand tended to pipe during drilling.									Piez. 1
	TRI-CONE	CONTINUED ON NEXT PAGE			9	SS	50				

DATA INPUT: BS OCT 13/91

S - ◆ 1 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1728

LOCATION: 7780.544N; 9273.828E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-18

BORING DATE: JULY 9,1991

SHEET 2 OF 2

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
30	POWER AUGER BORING 20cm CORE	CONTINUED FROM PREVIOUS PAGE LOWER SAND CONT'D			8	WS		SHEAR STRENGTH Cu, kPa: rem V - ● ; nat V - + Q - ● U - ○	WATER CONTENT, PERCENT: Wp, W, Wl		
32	CASE 61	END OF BOREHOLE Borehole terminated in sand.		486.21 21.58	10	SS	50/30 7"				WATER LEVEL IN PIEZ. 1 AT ELEV. 505.25m ON SEP. 25/91 WATER LEVEL IN PIEZ. 2 AT ELEV. 517.50m ON SEP. 18/91
34											
36											
38											
40											
42											
44											
46											

DATA INPUT: 24 OCT 1991

31.0-1 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RS

PROJECT: 911-1726

RECORD OF BOREHOLE GA-19

SHEET 1 OF 1

LOCATION: 7286.212N; 10105.579E

BORING DATE: JULY 8,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (rem V. ÷ Q. ●; rem V. ● U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, WI; 10, 20, 30, 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		517.28 0.00							
		ALLUVIUM Loose, light brown SILT and SAND, some gravel.			1	SS	6				Water level reference Elev. 517.98m BENTONITE SEAL
				515.98 1.30							
2		UPPER LACUSTRINE CLAY Soft to firm, dark red brown, laminated CLAYEY SILT with minor fine sand and silt lamination, moist to wet.			2	SS	4				
					3	ST					SILICA SAND Pez. 3
4					4	ST					
					5	SS	6				BENTONITE SEAL
6				508.78 7.50							SILICA SAND Pez. 2
		RED TILL Very stiff, medium red brown CLAYEY SILT and SAND, some gravel, moist. (TILL)			6	SS	30				
8					7	SS	37				
				508.78 10.50							
10					8	SS	50/0				BENTONITE SEAL
		White GYPSUM NOTE: Drill water circulation retained throughout bedrock.									SILICA SAND Pez. 1
12											
				502.69 15.24							
14		END OF BOREHOLE									
16											
18											
20											

BORING METHOD: 200 mm DIA POWER AUGER BORING; HOLLOW STEM AUGERING; 150 mm DIA ROCK CORING

DYNAMIC PENETRATION RESISTANCE: ● 5 PERCENT AXIAL STRAIN AT FAILURE

WATER LEVEL IN PEZ. 1 AT ELEV. 515.50m AND IN PEZ. 2 AT ELEV. 516.12m AND IN PEZ. 3 AT ELEV. 516.68m ON SEP. 25/91

DATA INPUT: BR, OCT 10/91

DEPTH SCALE
1 to 100

Golder Associates

LOGGED: AJC
CHECKED: RB

PROJECT: 911-1726

LOCATION: 7043.017N; 8874.507E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-20

BORING DATE: JULY 20,1991

SHEET 1 OF 1

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		521.48 / 0.00							
		UPPER SAND Loose, medium brown, interbedded, fine to coarse SAND, some silt; samples dry then becoming moist to wet below 6.0m.			1	SS	15				Water level reference Elev. 522.153m BENTONITE SEAL
2					2	SS	6				
4											
6					3	SS	5				
8											
10					4	SS	9				SILICA SAND
12				509.88 / 11.92							
		RED TILL Hard, dark red brown CLAYEY SILT and SAND, some gravel, moist. (TILL)			5	SS	79				
14											
16					6	SS	111				Pea. 1
		BEDROCK SURFACE		509.68 / 12.00							
18		Grey CARBONATE									
20				503.74 / 18.74							
		END OF BOREHOLE									REZ. 1 DRY AT ELEV. 503.16m ON SEP 20/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: GM

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-21

SHEET 1 OF 1

LOCATION: 7235.020N; 8599.724E

BORING DATE: JULY 20-21,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		514.11				SHEAR STRENGTH Cu, kPa: nat V - +, rem V - ●, Q - ●, U - ○	WATER CONTENT, PERCENT: Wp, W, Wl (10, 20, 30, 40)		Water level reference Elev. 514.528m.
		PEAT Dark brown to dark grey, fibrous PEAT and SILTY ORGANIC SOIL.		0.00	1	AS					BENTONITE SEAL
				512.61							
2		UPPER SAND		1.50	2	AS					SILICA SAND
		Medium brown SILTY SAND to fine SAND with layers of silt; moist to wet.			3	AS					
4					4	AS					
					5	AS					Piez. 1
6					6	AS					
				504.97							
		END OF BOREHOLE		9.14							WATER LEVEL IN PIEZ. 1 AT ELEV. 509.57m ON SEP. 16/91.
10		NOTE: All soil samples taken from auger cutting.									
12											
14											
16											
18											
20								5 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: SK OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: GM/LG

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-22A

SHEET 1 OF 2

LOCATION: 7178.207N; 8263.366E

BORING DATE: AUG. 8-9,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. +, Q. ●; rem V. ●, U. ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		518.16							
		UPPER SAND Compact to dense, light to medium brown, interbedded SILTY SAND, fine SAND and CLAYEY SILT.		0.00	1	SS	21				Water level reference Elev. 518.373m. BENTONITE SEAL
2											
					2	SS	13				
4											
6											
					3	SS	38				
8											
10				507.16							
		RED TILL Hard, medium red brown CLAYEY SILT and SAND, some gravel, moist. (TILL)		11.00	4	SS	62				SILICA SAND
12											
		Becomes dark reddish brown below 15m depth.			5	SS	39				
14											
					6	SS	37				
16											
18											
20		CONTINUED ON NEXT PAGE						15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: BK, OCT 13/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: LGJM

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7178.207N; 8263.368E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-22A

BORING DATE: AUG. 8-9,1991

SHEET 2 OF 2

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. ÷, rem V. ●, Q ●, U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME-55 POWER AUGER BORING; HOLLOW STEM AUGERS	CONTINUED FROM PREVIOUS PAGE									
		RED TILL CONT'D			7	SS	62				
24				484.10 / 24.00							
		CRETACEOUS CLAY Hard, light to dark grey, laminated to massive textured CLAYEY SILT and SAND, trace to some gravel, trace black carbon (wood). Gravel clasts predominantly quartz pebbles.			8	SS	50				SILICA SAND
26					9	SS					
					10	SS	50/ 13			MH	
30					11	SS	72				
32		BEDROCK SURFACE		481.10 / 33.00							
	IRI-CONE	White GYPSUM			12	SS	50				Pez. 1
36				481.39 / 36.59							
		END OF BOREHOLE NOTE: Retained drill water circulation throughout bedrock.									WATER LEVEL IN PEZ. 1 AT ELEV. 500.80m ON SEP. 26/91.
40								15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: BR, OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: LG/JM

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7179.847N; 8286.490E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-22B

BORING DATE: JULY 21,1991

SHEET 1 OF 1

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		518.54 / 0.00							
	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	UPPER SAND Compact to dense, light to medium brown, interbedded SILTY SAND, fine SAND and CLAYEY SILT.			1	AS					Water level reference Elev. 518.998m. BENTONITE SEAL
2					2	AS					
4					3	AS					SILICA SAND
					4	AS					
6					5	AS					Piez. 1
					6	AS					
8				509.40							
		END OF BOREHOLE		9.14							PIEZ. 1 DRY ON SEP 25/91.
10											
12											
14											
16											
18											
20											

SHEAR STRENGTH Cu, kPa — rem V: ● U: ○ — nat V: + Q: ⊗

WATER CONTENT, PERCENT: Wp 10 20 30 40 W Wl

15 to 5 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SH OCT 10/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 6824.277N; 8538.473E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-23

BORING DATE: JULY 21-23,1991

SHEET 1 OF 4

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ●, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		536.83 0.00							
0	LOWER CAT 35 WASH BORING TRI-CONE	UPPER SAND Medium brown SAND and SILTY SAND, minor clayey silt layers.			1	WS					Water level reference Elev. 536.170m. BENTONITE SEAL
2											
4											
6		NOTE: Very poor definition of soil stratigraphy due to condition of wash samples returned to surface.Tricone drilling with Malex addative.			2	WS					
8											
10					3	WS					
12											
14					4	WS					
16					5	WS					
18					6	WS					
20		CONTINUED ON NEXT PAGE						15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE			

DATA INPUT: SK OCT 17/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-23

SHEET 2 OF 4

LOCATION: 6824.277N; 8536.473E

BORING DATE: JULY 21-23,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V ◆ rem.V ● Q ● U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s	WATER CONTENT, PERCENT (Wp, W, WI; 10 20 30 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	LONGYEAR 38 WASH BORING N TRI-CONE	CONTINUED FROM PREVIOUS PAGE UPPER SAND CONT'D Medium brown SAND and SILTY SAND, minor clayey silt layers.			9	WS						
22					7	WS						
24					8	WS						
26					9	WS						
28					10	WS						
30					11	WS						
32					12	WS						
34					13	WS						
36		CONTINUED ON NEXT PAGE						15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE				

DATA INPUT: BR, OCT 17/91

DEPTH SCALE
1 to 100

Golder Associates

LOGGED: AJC
CHECKED: RB

PROJECT: 911-1728

RECORD OF BOREHOLE GA-23

SHEET 3 OF 4

LOCATION: 6824.277N; 8538.473E

BORING DATE: JULY 21-23,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V. + Q - ●, rem.V. ● U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
40	LOWERED AS WASH BORING IN TIN CONE	CONTINUED FROM PREVIOUS PAGE									
		UPPER SAND CONT'D			13	WS					
41					14	WS					
42											
43					15	WS					
				466.83 47.00							
44		Medium brown CLAYEY SILT.									
45				465.02 50.00	16	WS					
		RED TILL									
46		Medium red brown CLAYEY SILT and SAND, some gravel. (TILL)									
47					17	WS					
48					18	WS					
49					19	WS					
50		CONTINUED ON NEXT PAGE						10 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE 15			

DATA INPUT: BS OCT 17/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 6824.277N; 8538.473E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-23

BORING DATE: JULY 21-23,1991

SHEET 4 OF 4

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. ◆ Q ● rem V. ● U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
80	LOM/REAR 30 WASH BORING & TRI-CORE	CONTINUED FROM PREVIOUS PAGE									
		RED TILL CONT'D			19	WS					
82					20	WB					
84											Piez. 1
86		BEDROCK SURFACE		469.83 85.80	21	WB					
		Grey CARBONATE									
		END OF BOREHOLE		469.37 87.06							PIEZ. 1 DRY AT ELEV. 470.49m ON SEP. 25/91
88		NOTE: Borehole was wash bored using Matex in drill water flush.									
70											
72											
74											
76											
78											
80											

DATA INPUT: BK OCT 17/91

Shear strain, percent axial strain at failure

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7414.168N; 9002.796E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-24

BORING DATE: JULY 22,1991

SHEET 1 OF 1

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		514.98 0.00				SHEAR STRENGTH Cu, kPa: rem V - ● rat V - + Q - ● U - ○	WATER CONTENT, PERCENT: Wp, W, Wl; 10 20 30 40		Water level reference Elev. 513.667m. BENTONITE SEAL; SILICA SAND; Piez. 1
2		Light to medium CLAYEY to SANDY SILT, trace gravel, some root material.			1	AS					
4					2	AS					
6					3	AS					
8					4	AS					
10		NOTE: All soil samples taken from auger cuttings only. Stratigraphy description not considered entirely representative.			5	AS					
12					6	AS					
14					7	AS					
16		END OF BOREHOLE		504.31 10.67							WATER LEVEL IN PIEZ. 1 AT ELEV. 513.38m ON SEP 25/91
18											
20											

Cam 55 POWER AUGER BORING; HOLLOW STEM AUGERS

Data input: BK, OCT 10/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: LB

CHECKED: RB

PROJECT: 911-1728

LOCATION: 7414.78SN; 8760.58E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-25

BORING DATE: JULY 23,1991

SHEET 1 OF 1

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Dia 83 POWER AUGER BORING HOLLOW STEM AUGERS	GROUND SURFACE		514.69 0.00							
		Light to medium CLAYEY to SANDY SILT, trace gravel, some root material.			1	AS					Water level reference Elev. 12 514.58 TOP BENTONITE SEAL
2					2	AS					
4					3	AS					SILICA SAND
					4	AS					
6		NOTE: All soil samples taken from auger cuttings only. Stratigraphy description not considered entirely representative.			5	AS					Pez. 1
					6	AS					
8				505.11 9.14							
		END OF BOREHOLE									WATER LEVEL IN PEZ. 1 AT ELEV. 514.09m ON SEP. 05/91
10											
12											
14											
16											
18											
20											

SHEAR STRENGTH Cu, kPa: nat V. + ; rem V. ● ; Q - ● ; U - ○

WATER CONTENT, PERCENT: wp, w, wl; 10, 20, 30, 40

DATA INPUT BY: OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: LG

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-26

SHEET 1 OF 1

LOCATION: 7343.825N; 8486.476E

BORING DATE: JULY 23-24, 1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (rem V ◆ ○, rem V ● U ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (wp, w, wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER (SOIL) HOLLOW STEM AUGERS	GROUND SURFACE		514.63 0.00							
		ALLUVIUM Loose, light brown to grey brown SILTY fine to coarse SAND, some gravel, trace root material, peat at surface, wet.			1	SS	6				Water level reference Elev. 515.07 top of riser BENTONITE SEAL SILICA SAND Piez. 2
2					2	SS	2				
				511.63 3.00							
4		RED TILL Hard, medium red brown CLAYEY SILT and SAND, some gravel, moist. (TILL)			3	SS	15				BENTONITE SEAL
					4	SS	37				SILICA SAND
6					5	SS	68				Piez. 1
					6	SS	52				
8				505.49 9.14							
		END OF BOREHOLE									WATER LEVEL IN PIEZ. 1 AND IN PIEZ. 2 AT ELEV. 514.32m ON 95/9/ 25/91
10											
12											
14											
16											
18											

DATA INPUT: BS OCT 07/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: LG

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-27

SHEET 1 OF 2

LOCATION: 7126.804N; 8123.087E

BORING DATE: AUG. 6-8,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. ○ ● ; rem V. ● ○)	HYDRAULIC CONDUCTIVITY, k, cm/s	WATER CONTENT, PERCENT (Wp, W, WI)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		327.33 0.00								Water level reference Elev. 327.6±2m
		UPPER SAND Loose, medium brown SAND and SILT, some gravel.		325.33 2.00	1	SS	9				SIH	
		RED TILL Very stiff to hard, medium red brown CLAYEY SILT and SAND, some gravel; moist. (TILL)			2	SS	23					
					3	SS	28					
					4	SS	28					
					5	SS	13					SILICA SAND
					6	SS	23					
					7	SS	46					
					8	SS	50/15cm					BENTONITE SEAL
		LOWER SAND Very dense, grayish brown SAND; wet. NOTE: Sand piped into augers.		309.33 18.00	9	SS	63				SIH	SILICA SAND
		CONTINUED ON NEXT PAGE		307.33 20.00	10	SS	7				SIH	

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: LG

CHECKED: RB

PROJECT: 911-1726

LOCATION: 7128.804N; 9123.087E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-27

BORING DATE: AUG. 6-8,1991

SHEET 2 OF 2

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	SHEAR STRENGTH Cu, kPa (rem V ✦ Q ●; rem V ● U ○)	WATER CONTENT, PERCENT (wp, w, wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	CME 55 DOWN-THE-HOLE HAMMER (CASING) HOLLOW STEM AUGERS	CONTINUED FROM PREVIOUS PAGE		507.33									
		LOWER LACUSTRINE CLAY Hard, dark red brown, very thinly laminated CLAYEY SILT, trace fine sand grading downward to silty clay and clay, moist. - Trace gravel sized dropstones and laminations of sand occur near top of unit.		30.00	10	SS	1						
					11	SS	45						SILICA SAND
					12	SS	42						
					13	SS	31						
					14	SS	47						
		CRETACEOUS SAND Very dense, light grey, medium to coarse SAND, trace silt, well, sand grains are quartz, quartzite, carbonate, phyllite and quartz pyrite. NOTE: Lost drill water circulation at 33.5m.		476.33 33.00	15	SS							Piez. 1
		CRETACEOUS CLAY Grey CLAYEY SILT, some sand and black carbon fragments (wood)		461.33 48.00	16	SS	79						
		END OF BOREHOLE		459.43 50.90									WATER LEVEL IN PIEZ 1 AT ELEV. 508.7m ON SEP 25/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: LS

CHECKED: RB

PROJECT: 911-1758

LOCATION: 7663.217N, 9701.462E

SAMPLER HAMMER, 63.5kg, DROP, 760mm

RECORD OF BOREHOLE GA-28A

BORING DATE: AUG. 14-16,1991

SHEET 1 OF 3

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, K, cm/s	WATER CONTENT PERCENT	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		540.53 0.00								
		UPPER SAND Loose, medium red brown SAND and SILT			1	SS (50)	9					Water level reference Elev 540.69m BENTONITE SEAL
2		RED TILL		538.53 2.00								
		Hard, medium red brown CLAYEY SILT and SAND, some gravel, moist, (TILL)			2	SS (50)	45					
4					3	SS (50)	71					
6		Changes to dark red brown below 6.0m depth.			4	SS (50)	42					
					5	SS (50)	16					
8					6	SS (50)	65					
10												SILICA SAND
12					7	SS (50)	45					
14												
16		Till becomes coarse grained silt and sand, some gravel, trace clay between 17.0m and 18.2m			8	SS (50)	71					
18		BEDROCK SURFACE		522.53 18.00								
		White GYPSUM										
20		CONTINUED ON NEXT PAGE										

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE QA-28A

SHEET 2 OF 3

LOCATION: 7663.217N; 9701.462E

BORING DATE: AUG. 14-16,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
30	DIE STD POWER AUGER (CORING) & TRICONE	CONTINUED FROM PREVIOUS PAGE						SHEAR STRENGTH Cu, kPa nat V: + ; rem V: ● ; U: ○ ; U: ●	WATER CONTENT, PERCENT wp ; w ; wl		
31		White GYPSUM									BLACK SAND
32											
33											
34											
35											
36											
37		CONTINUED ON NEXT PAGE									

ε1-3 = PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: DR OCT 12/91

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1798

LOCATION: 7863.517°S; 970.1.483E

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE GA-25A

BORING DATE: AUG. 14-18,1991

SHEET 3 OF 3

DATUM: MINE

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	SHEAR STRENGTH Cu, kPa (rem V: ○ ●; nat V: ● ○)	HYDRAULIC CONDUCTIVITY, k, cm/s	WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
40		CONTINUED FROM PREVIOUS PAGE											
42													
44													
46													SILICA SAND
48		White GYPSUM											
50		NOTE: Drill water circulation was retained throughout bedrock.											Piez. 1
52													
54													
56													
58		END OF BOREHOLE		156.60 57.61									WATER LEVEL IN PIEZ. 1 AT ELEV. 515.57m ON SEP 20/91
60													

DEPTH SCALE

1 to 100

Golder Associates

LOGGED: AJC

CHECKED: RB

PROJECT: 911-1726

RECORD OF BOREHOLE GA-28B

SHEET 1 OF 1

LOCATION: 7981.283N, 9702.63E

BORING DATE: AUG. 14-15,1991

DATUM: MINE

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (rem V: ● u: ○ / rem V: ○ u: ●)	HYDRAULIC CONDUCTIVITY, k, cm/s	WATER CONTENT, PERCENT (wp, w, wl)	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	CME 55 POWER AUGER BORING; HOLLOW STEM AUGERS	GROUND SURFACE		340.60 0.00								Water level reference Elev. 341.225m; BENTONITE SEAL
		UPPER SAND Loose, medium red brown SAND and SILT										
2				338.65 2.00								
		RED TILL Hard, medium red brown CLAYEY SILT and SAND, some gravel, moist. (TILL)										
4												
6		- Changes to dark red brown below 6.0m depth										SILICA SAND; Pez. 1
8												
10		NOTE: Borehole not sampled										
12				328.35 12.25								
		END OF BOREHOLE										WATER LEVEL IN PEZ. 1 AT ELEV. 340.27m ON SEP. 25/91
14												
16												
18												
20												

SHEAR STRENGTH: 10 ● 5 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE
1 to 100

Golder Associates

LOGGED: AJC
CHECKED: RB

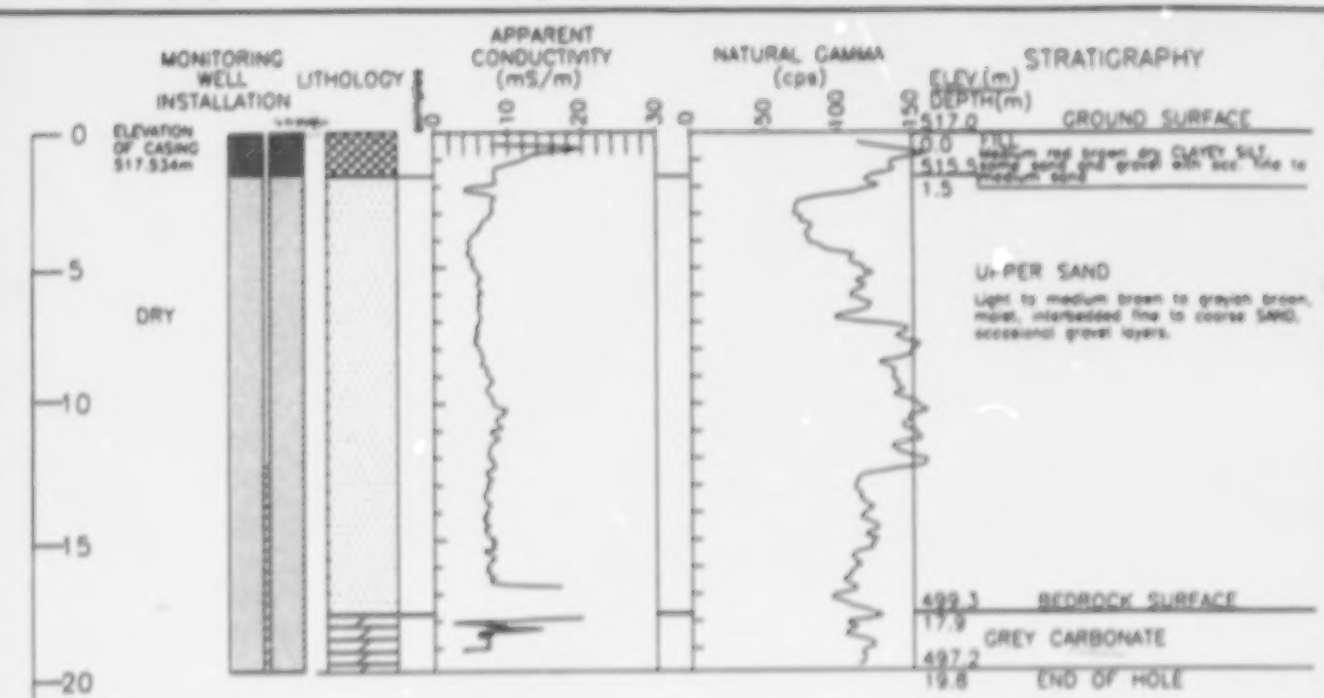
APPENDIX B

BOREHOLE GEOPHYSICS

Golder Associates Boreholes - 1991	GA-4, GA-5, GA-7, GA-8A, GA-9A, GA-10A, GA-14A, GA-20, GA-21, GA-22A, GA-23, GA-24, GA-27, GA-28A
Pre-existing Monitoring Wells	ETW-1, ETW-2, ETW-3, ETW-4 DW-1, DW-2, DW-3 OW-1A, OW-2, OW-3, OW-4, OW-6 H-3, H-4, H-5

RECORD OF BOREHOLE GA-4

Location 7138.437N 8441.968E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled JULY 19, 91
Datum MINE | Drilling Method POWER AUGER/TRICONE | Date Installed JULY 19, 91



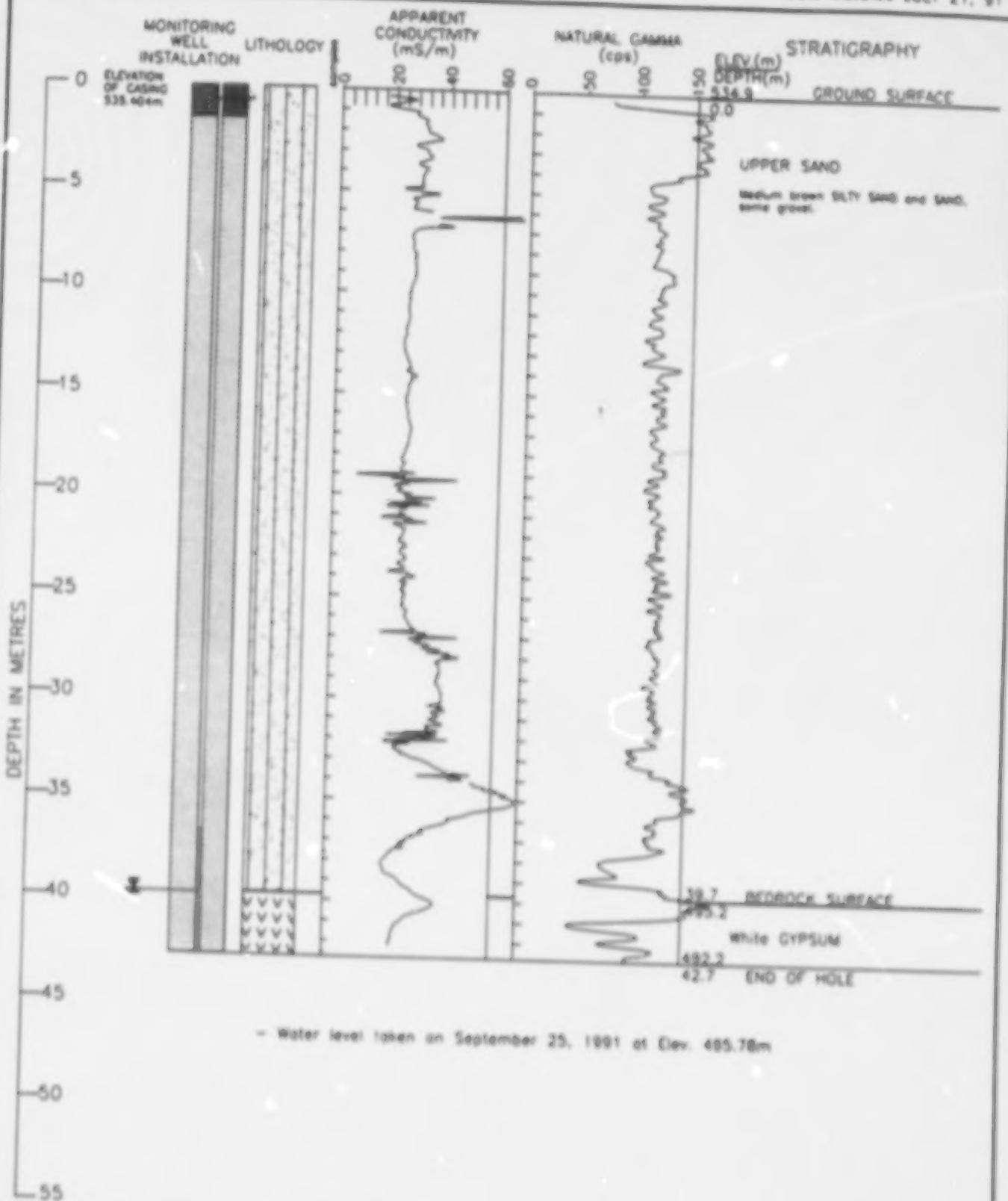
DEPTH IN METRES

- Water level measured on September 25, 1991
- Piezometer dry at Elev. 497.48m.

Project No. 911-1726 | Scale 1:250 | Golder Associates | Logged RB | Checked RB

RECORD OF BOREHOLE GA-5

Location 7017.353N 8321.728E
Datum MINE
Drilling Contractor LOGAN DRILLING LTD.
Drilling Method TRICONE
Date Drilled JULY 18-21,91
Date Installed JULY 21, 91

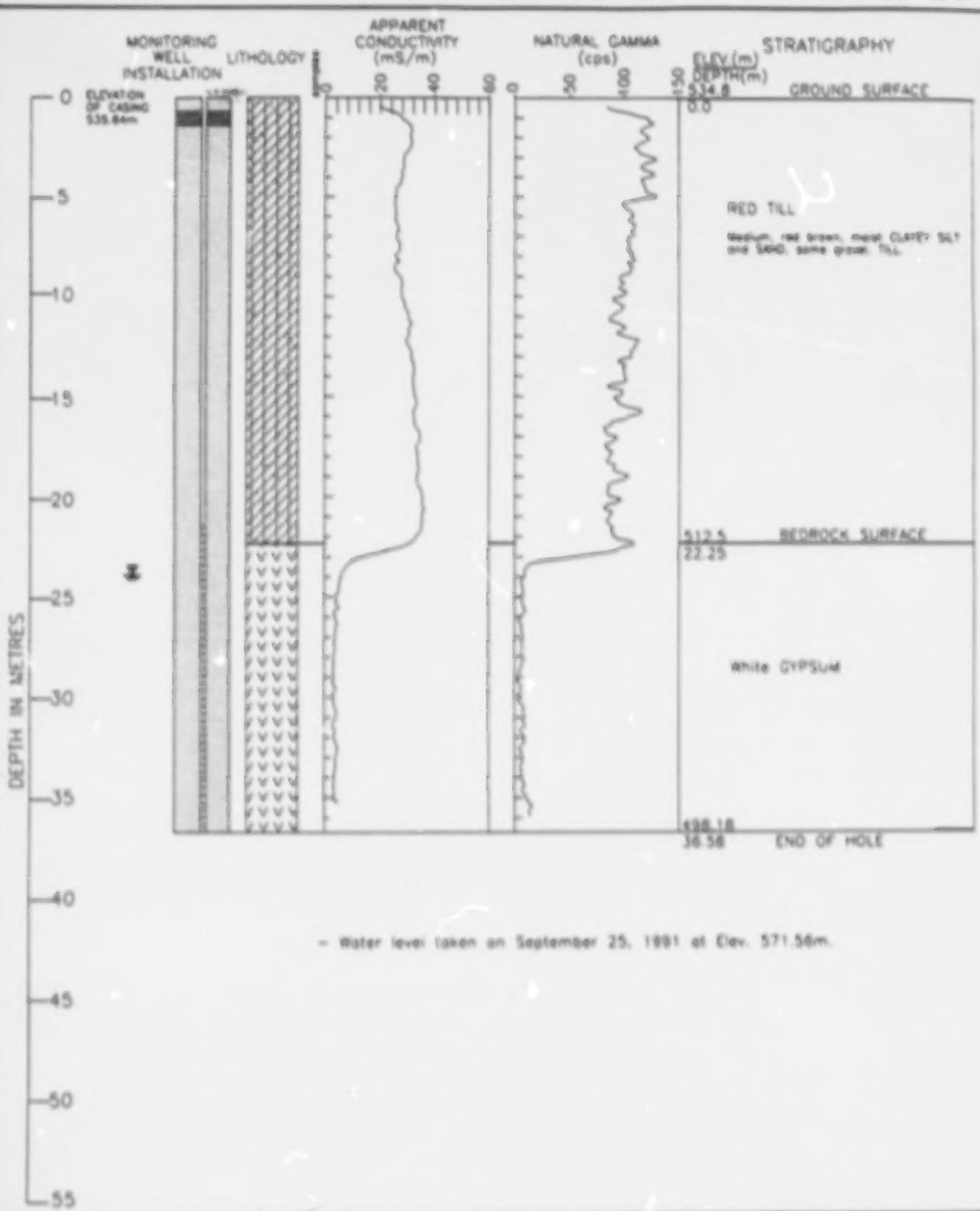


- Water level taken on September 25, 1991 at Elev. 495.78m

Project No. 911-1726
Scale 1:250
Golder Associates
Logged RB
Checked RB

RECORD OF BOREHOLE GA-7

Location 6774.648N 7758.687E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled AUG.10-12, 91
Datum MINE | Drilling Method POWER AUGER/TRICONE | Date Installed AUG. 12, 91

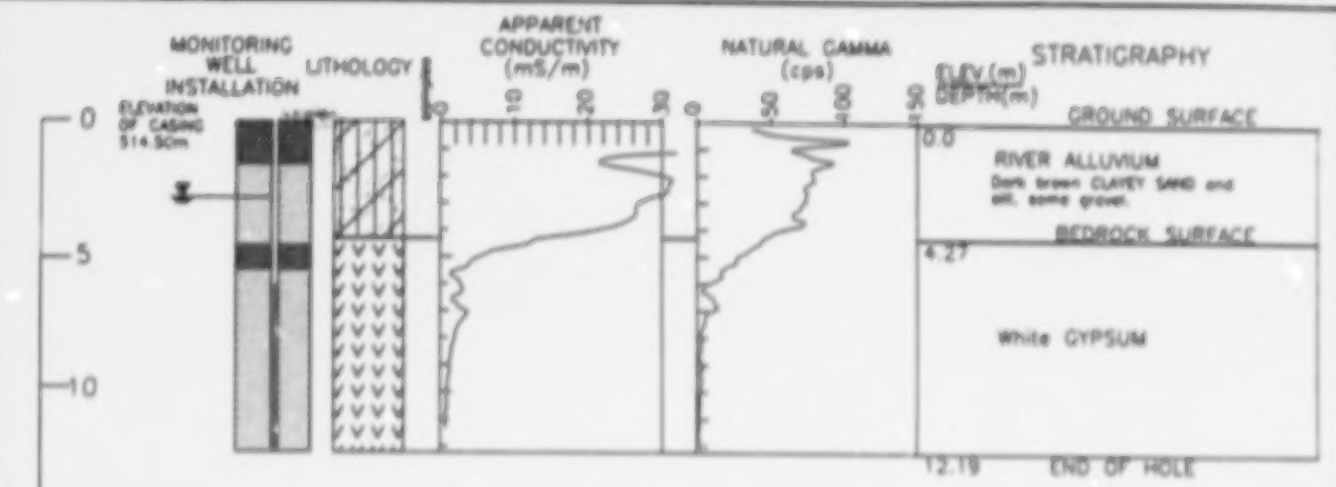


- Water level taken on September 25, 1991 at Elev. 571.56m.

Project No. 911-1726 | Scale 1:250 | Golder Associates | Logged RB | Checked RB

RECORD OF BOREHOLE GA-8A

Location 6503.915N 7242.850E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled JULY 31, 91
Datum MINE | Drilling Method POWER AUGER/TRICONE | Date Installed JULY 31, 91



DEPTH IN METRES

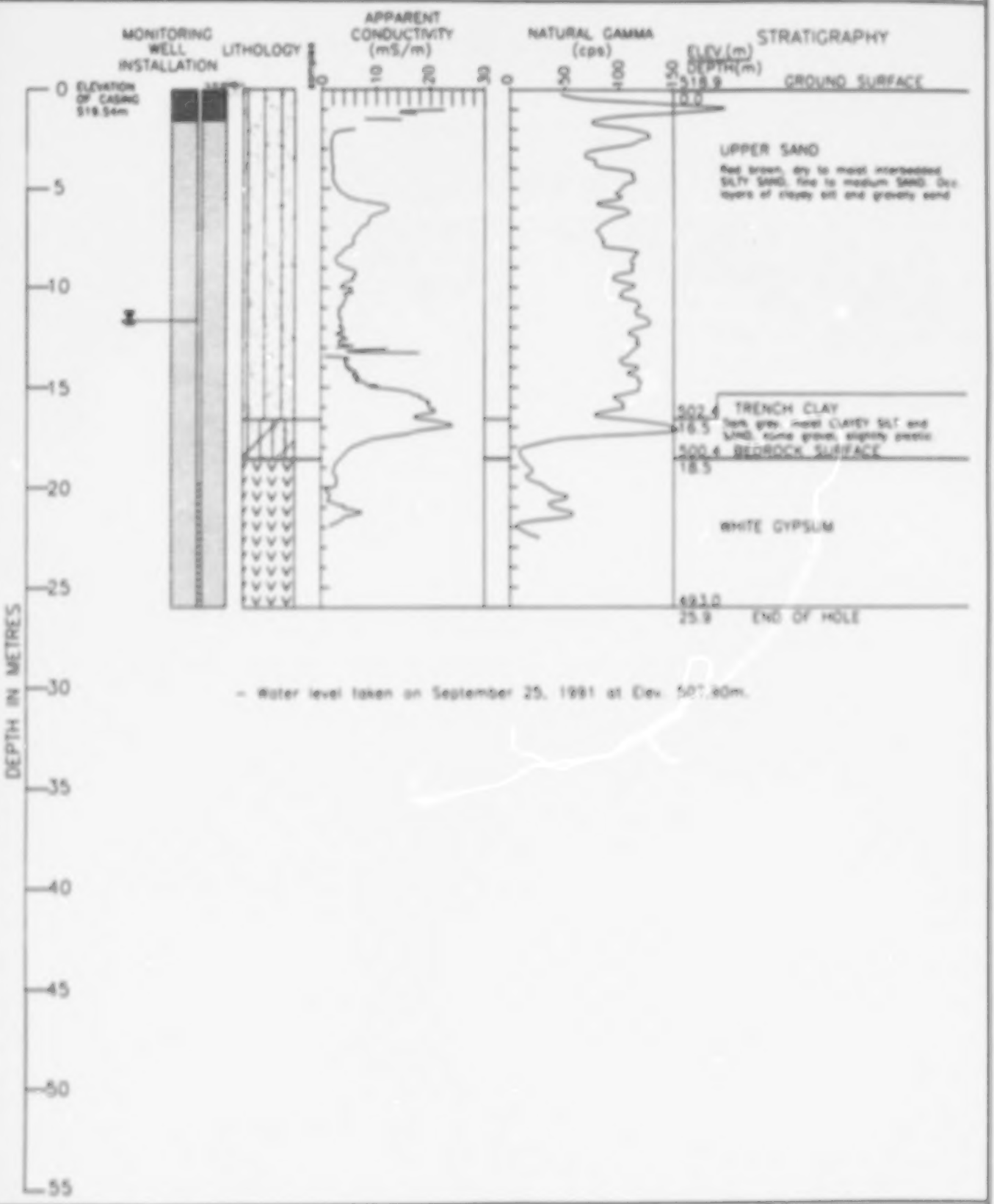
0 5 10 15 20 25 30 35 40 45 50 55

– Water level taken on September 25, 1991 at Elev. 511.66m.

Project No. 911-1726 | Scale 1:250 | Golder Associates | Logged RB | Checked RB

RECORD OF BOREHOLE GA-9A

Location 7035.667N 7741.694E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled JULY 29-30,91
Datum MINE | Drilling Method POWER AUGER/TRICONE | Date Installed JULY 30, 91



- Water level taken on September 25, 1991 at Elev. 507.60m.

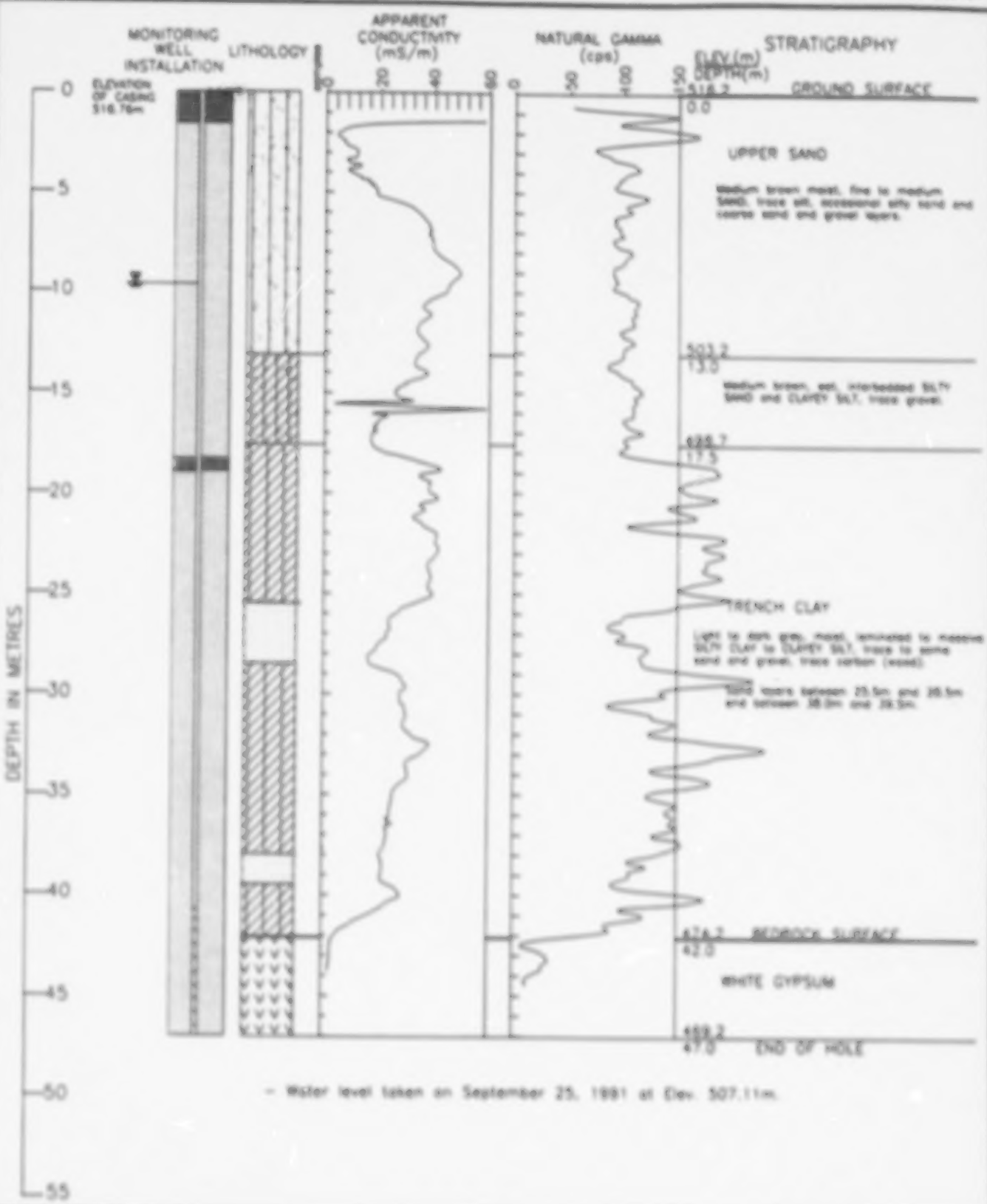
Project No. 911-1726 | Scale 1:250 | Golder Associates | Logged RB | Checked RB

RECORD OF BOREHOLE GA-10A

Location 7223.849N 7996.976E
Datum MINE

Drilling Contractor LOGAN DRILLING LTD.
Drilling Method POWER AUGER

Date Drilled JULY 26-28, 91
Date Installed JULY 28, 91



Project No. 911-1726

Scale 1:250

Golder Associates

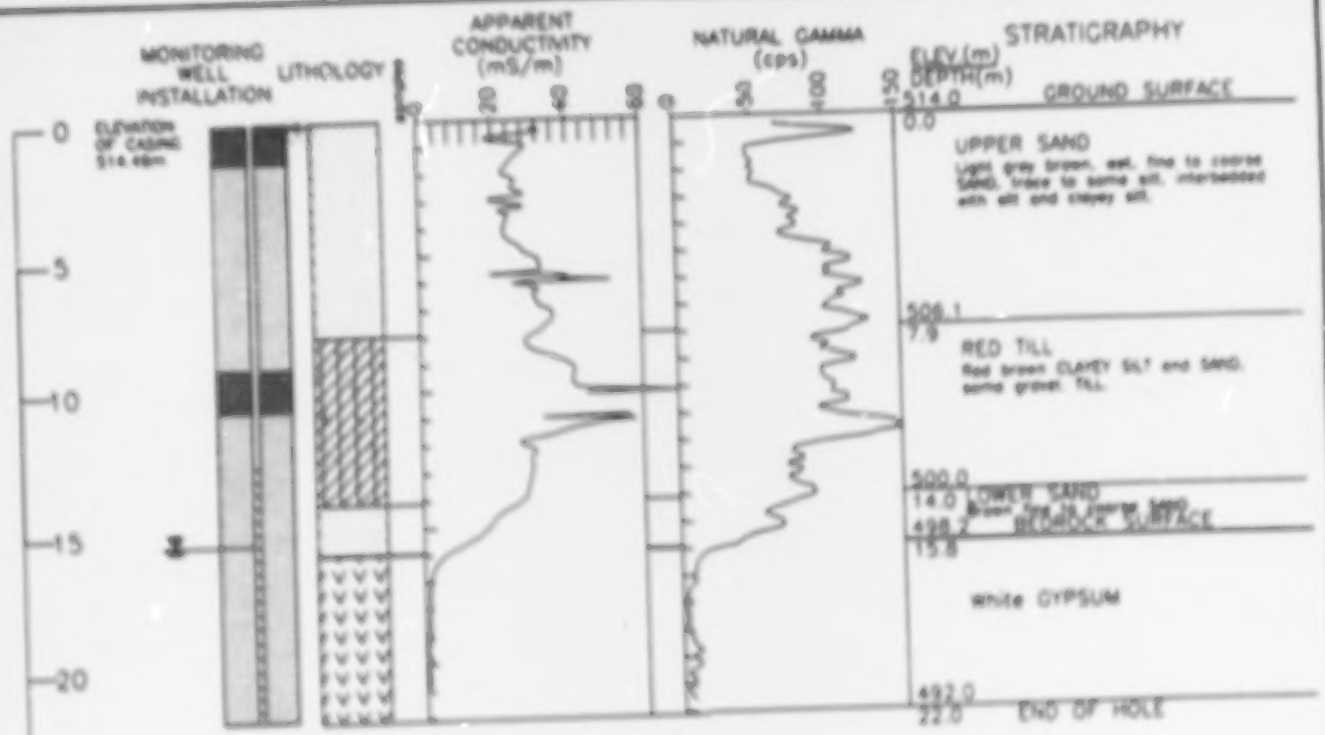
Logged RB
Checked RB

RECORD OF BOREHOLE GA-14A

Location 7299.490N 8348.537E
Datum MINE

Drilling Contractor LOGAN DRILLING LTD.
Drilling Method POWER AUGER/TRICONE

Date Drilled JULY 24-25,91
Date Installed JULY 25, 91



- water level taken on September 25, 1991 at Elev. 498.62m.

DEPTH IN METRES

Project No. 911-1726

Scale 1:250

Golder Associates

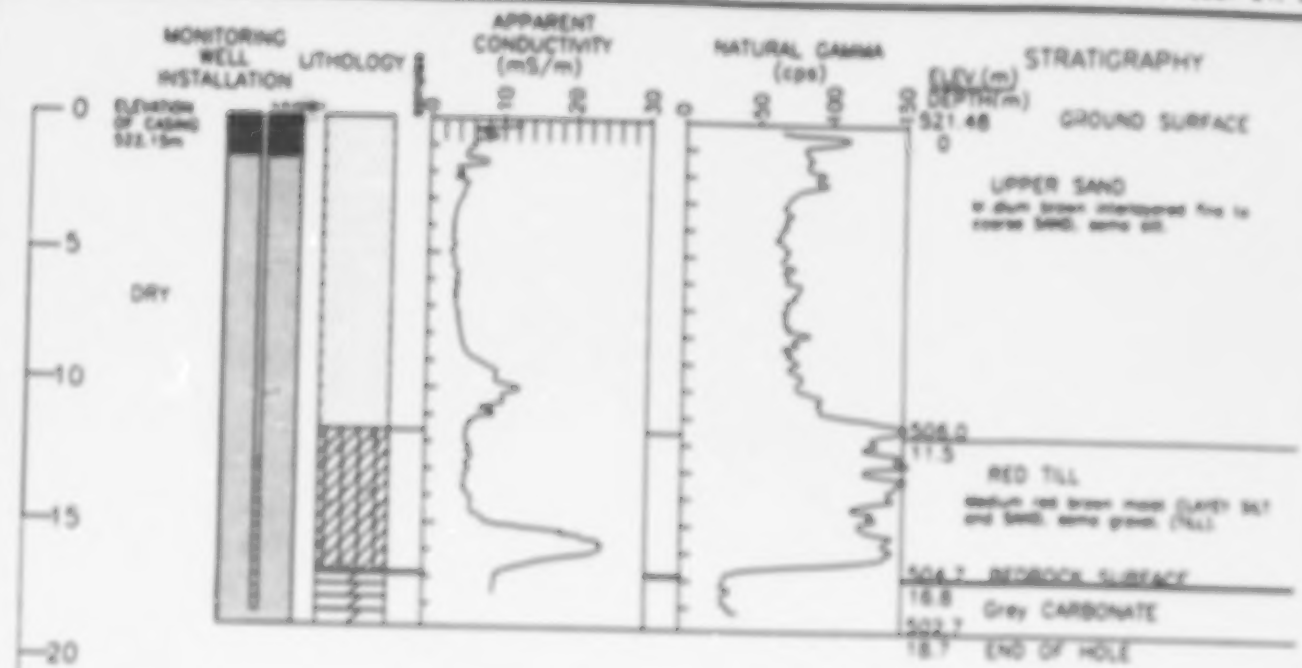
Logged RB
Checked RB

RECORD OF BOREHOLE GA-20

Location 7043 017N 8674.507E
Datum MINE

Drilling Contractor LOGAN DRILLING LTD.
Drilling Method POWER AUGER/TRICONE

Date Drilled JULY 20-21, 91
Date Installed JULY 21, 91



DEPTH IN METRES

0
5
10
15
20
25
30
35
40
45
50
55

- Water level taken on September 25, 1991
- Dry at Elev. 503.16m.

Project No. 911-1726

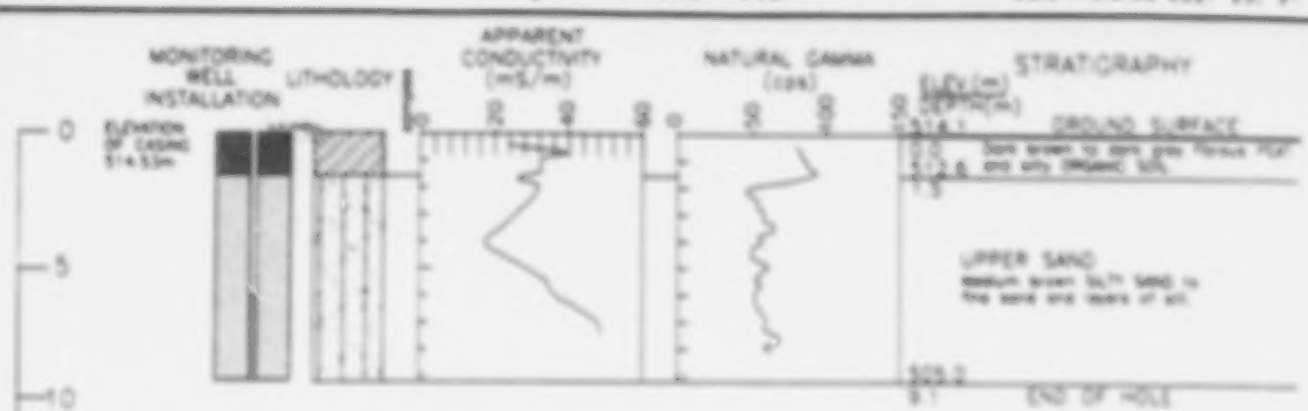
Scale 1:250

Golder Associates

Logged RB
Checked RB

RECORD OF BOREHOLE GA-21

Location 7235.020N 8599.724E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled JULY 20, 91
Datum MINE | Drilling Method POWER AUGER | Date Installed JULY 20, 91



▽ Water level taken on September 18, 1991 at Elev. 509.57m.

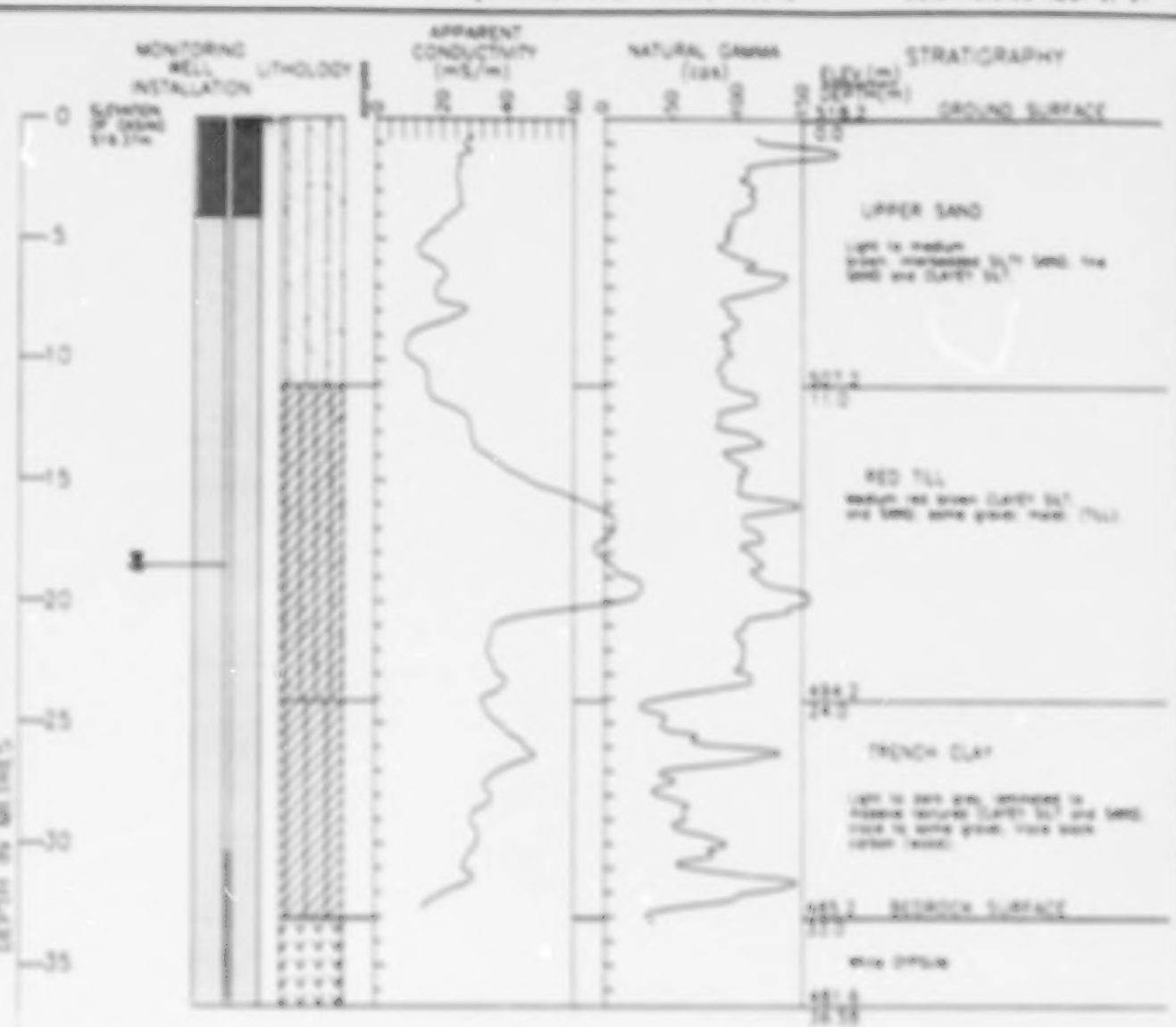
DEPTH IN METRES

0 5 10 15 20 25 30 35 40 45 50 55

Project No. 911-1728 | Scale 1:250 | Golder Associates | Logged RB | Checked RB

RECORD OF BOREHOLE GA-22A

Location 7178.207N 8263.366E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled AUG. 6-8,91
Datum MINE | Drilling Method POWER AUGER/TRICONE | Date Installed AUG. 9, 91



- Water level taken on September 23, 1991 at Elev. 500.80m.

Project No. 911-1728 | Scale 1:250 | Golder Associates | Logged: RB | Checked: RB

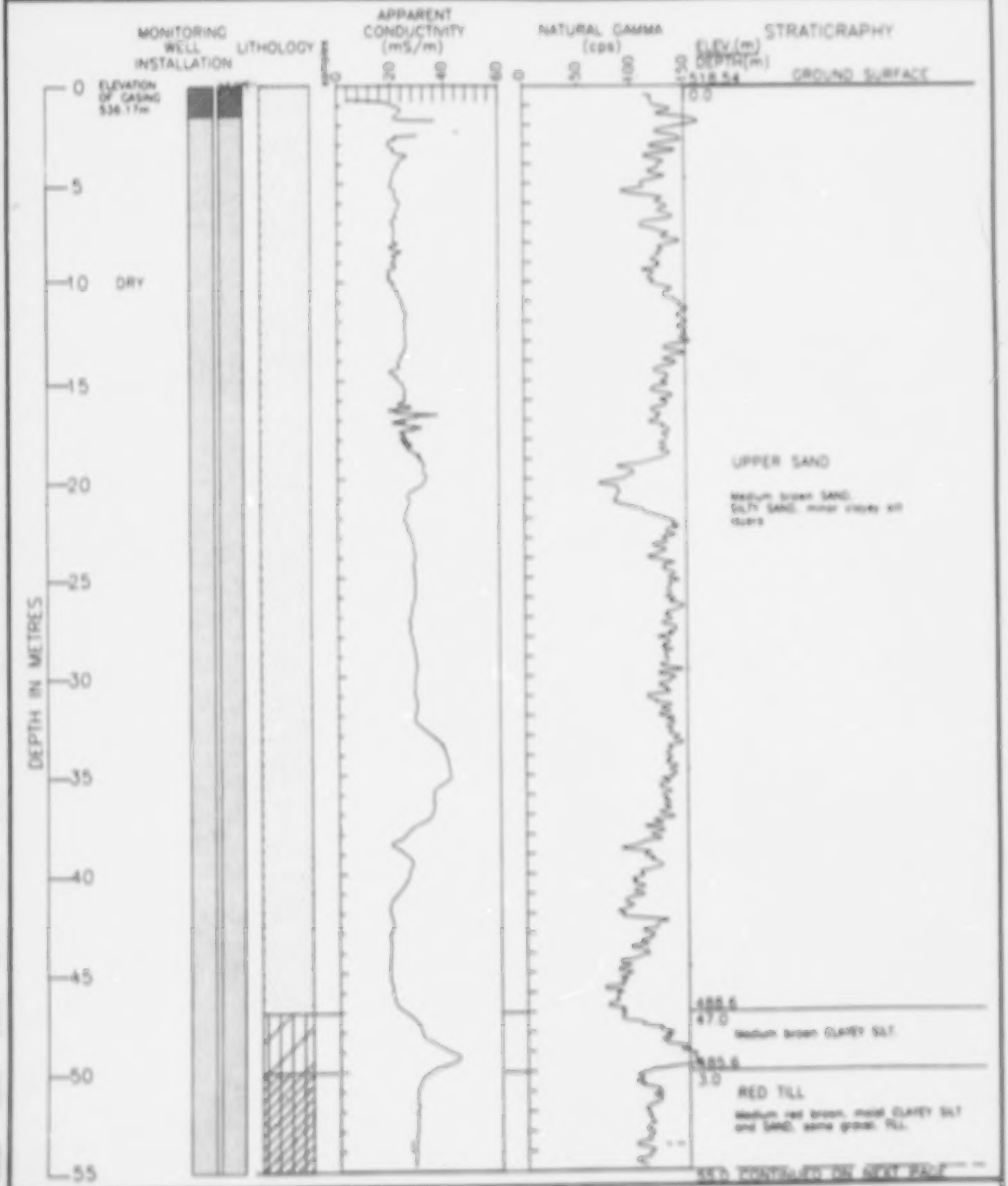
RECORD OF BOREHOLE GA-23

SHEET 1 OF 2

Location 6824.277N 8538.473E
Datum MINE

Drilling Contractor LOGAN DRILLING LTD.
Drilling Method TRICONE

Date Drilled JULY21-23, 91
Date Installed JULY 23, 91



Project No. 911-1726

Scale 1:250

Golder Associates

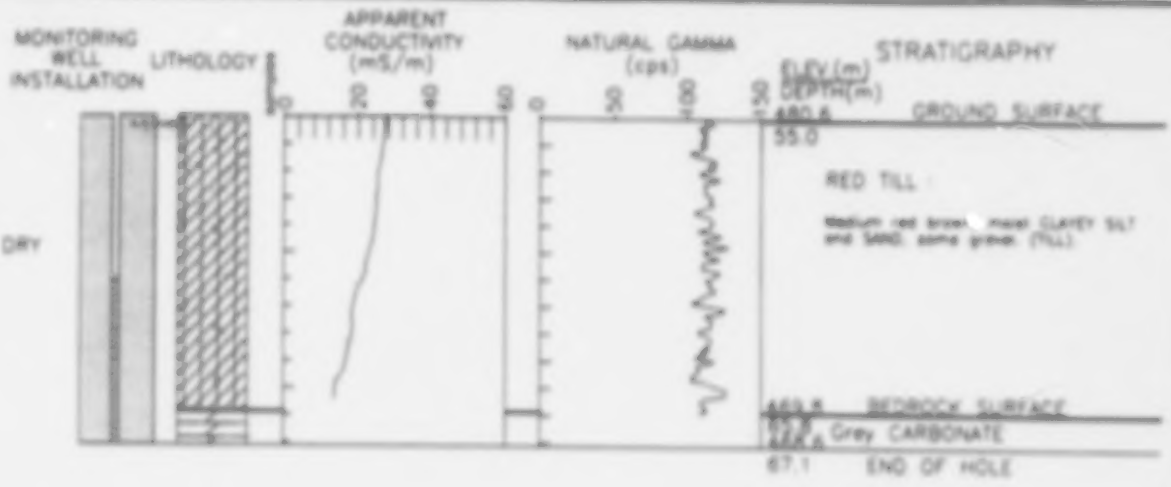
Logged RB
Checked RB

RECORD OF BOREHOLE GA-23

Location 6824.277N 8538.473E
Datum MINE

Drilling Contractor LOGAN DRILLING LTD.
Drilling Method TRICONE

Date Drilled JULY 21-23, 91
Date Installed JULY 23, 91



- Water level taken on September 23, 1991
- Piezometer dry at Elev. 470.49m.



Project No. 911-1726

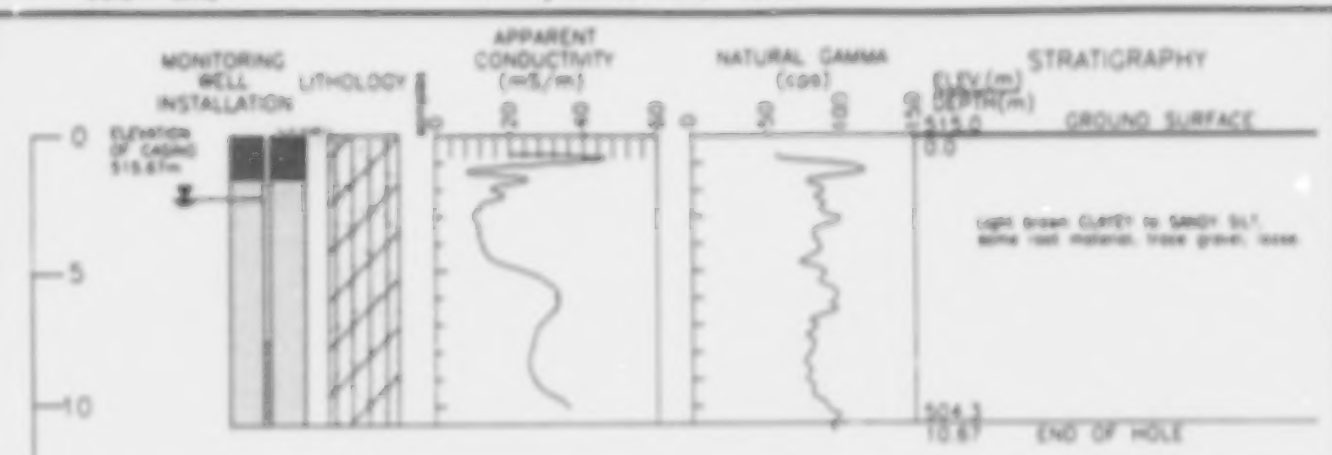
Scale 1:250

Golder Associates

Logged RB
Checked RB

RECORD OF BOREHOLE GA-24

Location 7414.168N 9022.798E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled JULY 23-24,91
Datum MINE | Drilling Method POWER AUGER | Date Logged JULY 24, 91



- Water level taken on September 23, 1991 at Elev. 513.28m

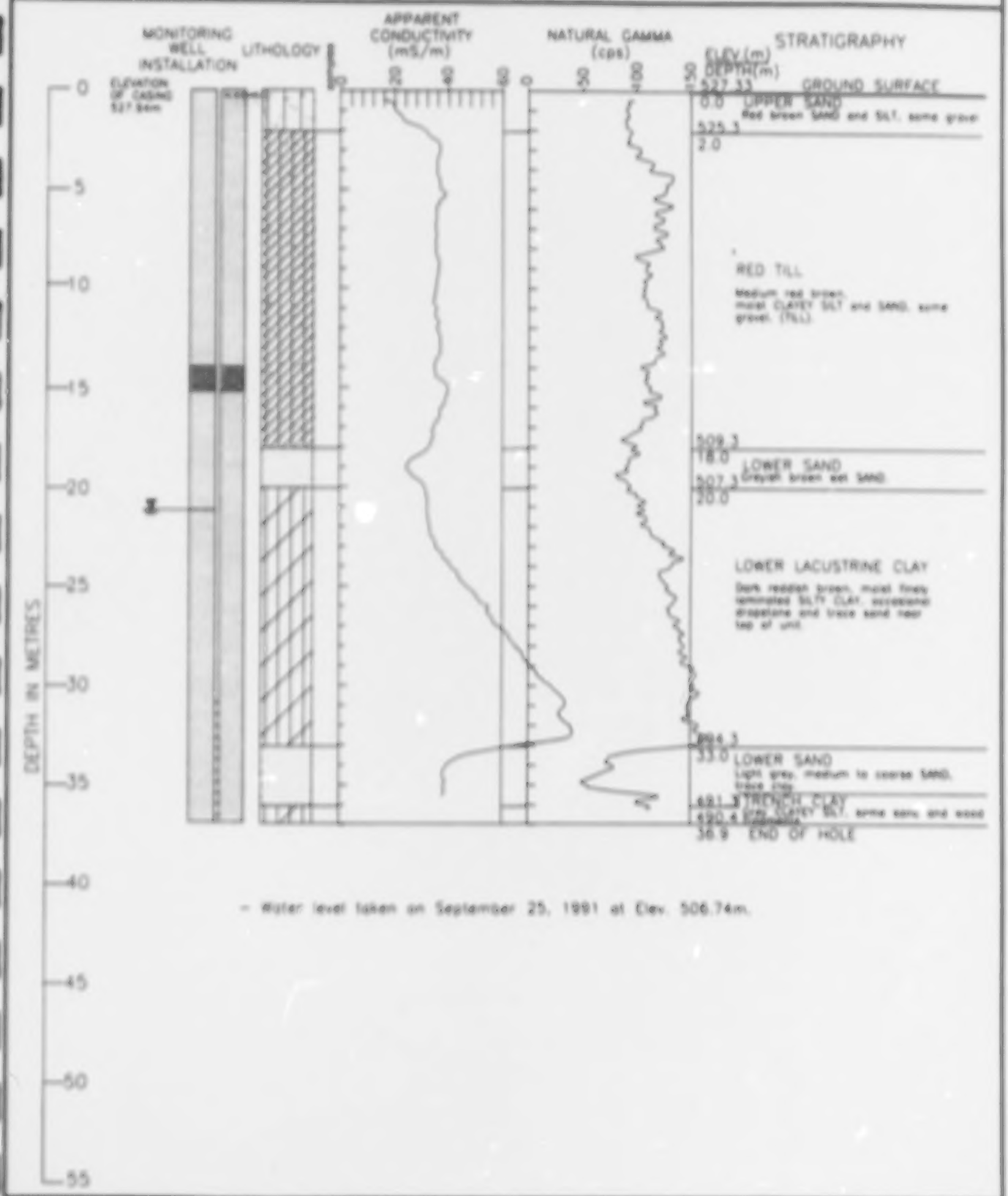
DEPTH IN METRES

0 5 10 15 20 25 30 35 40 45 50 55

Project No. 911-1726 | Scale 1:250 | Golder Associates | Logged RB | Checked RB

RECORD OF BOREHOLE GA-27

Location 7128.804N 6123.087E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled JULY 23-24,91
Datum MINE | Drilling Method POWER AUGER | Date Installed JULY 24, 91



- Water level taken on September 25, 1991 at Elev. 506.74m.

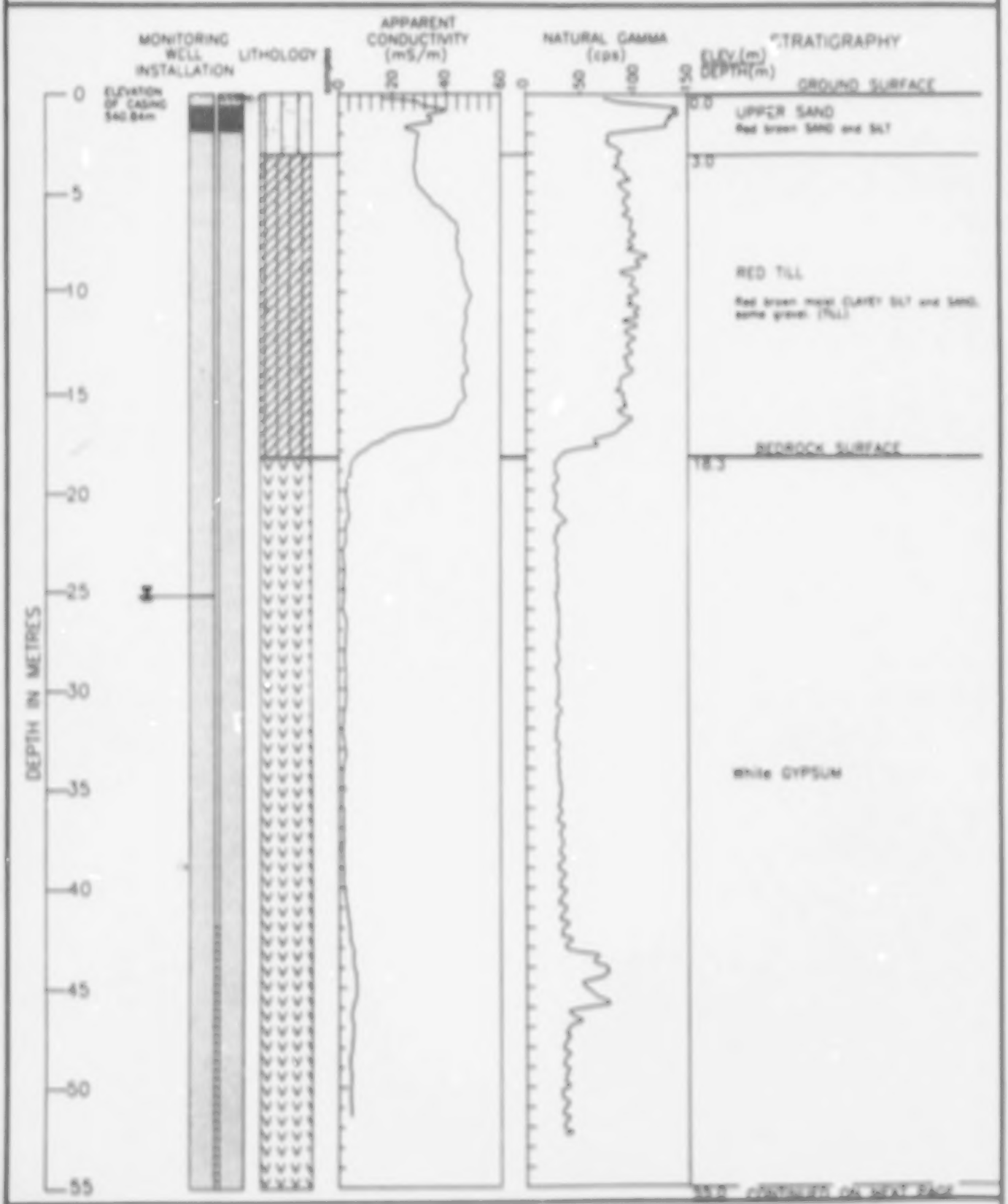
Project No. 911-1726 | Scale 1:250 | Golder Associates | Logged RB | Checked RB

RECORD OF BOREHOLE GA-28A

SHEET 1 OF 2

Location 7663.217N 9701.462E | Drilling Contractor LOGAN DRILLING LTD. | Date Drilled AUG.14-16, 91

Datum MINE | Drilling Method POWER AUGER/TRICONE | Date Installed AUG. 16, 91



CONTINUED ON NEXT PAGE

Project No. 911-1726

Scale 1:250

Golder Associates

Logged RB

Checked RB

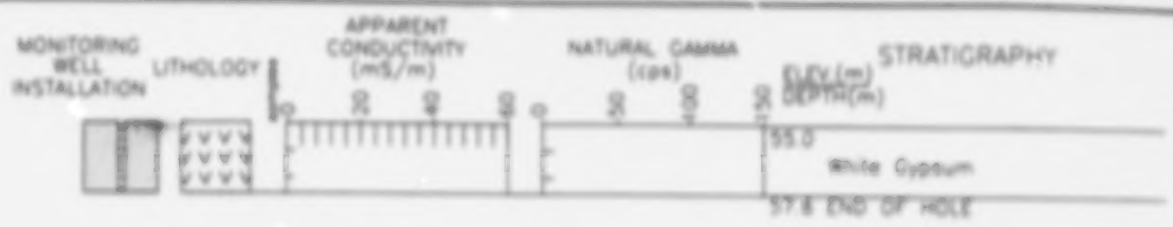
RECORD OF BOREHOLE GA-28

SHEET 2 OF 2

Location 7663.217N 9701.462E
Datum MINE

Drilling Contractor LOGAN DRILLING LTD.
Drilling Method POWER AUGER/TRICONE

Date Drilled AUG.14-16, 91
Date Installed AUG. 31, 91



DEPTH IN METRES

55
60
65
70
75
80
85
90
95
100
105
110

- Water level taken on September 25, 1991 at Elev. 515.57m.

Project No. 911-1728

Scale 1:250

Golder Associates

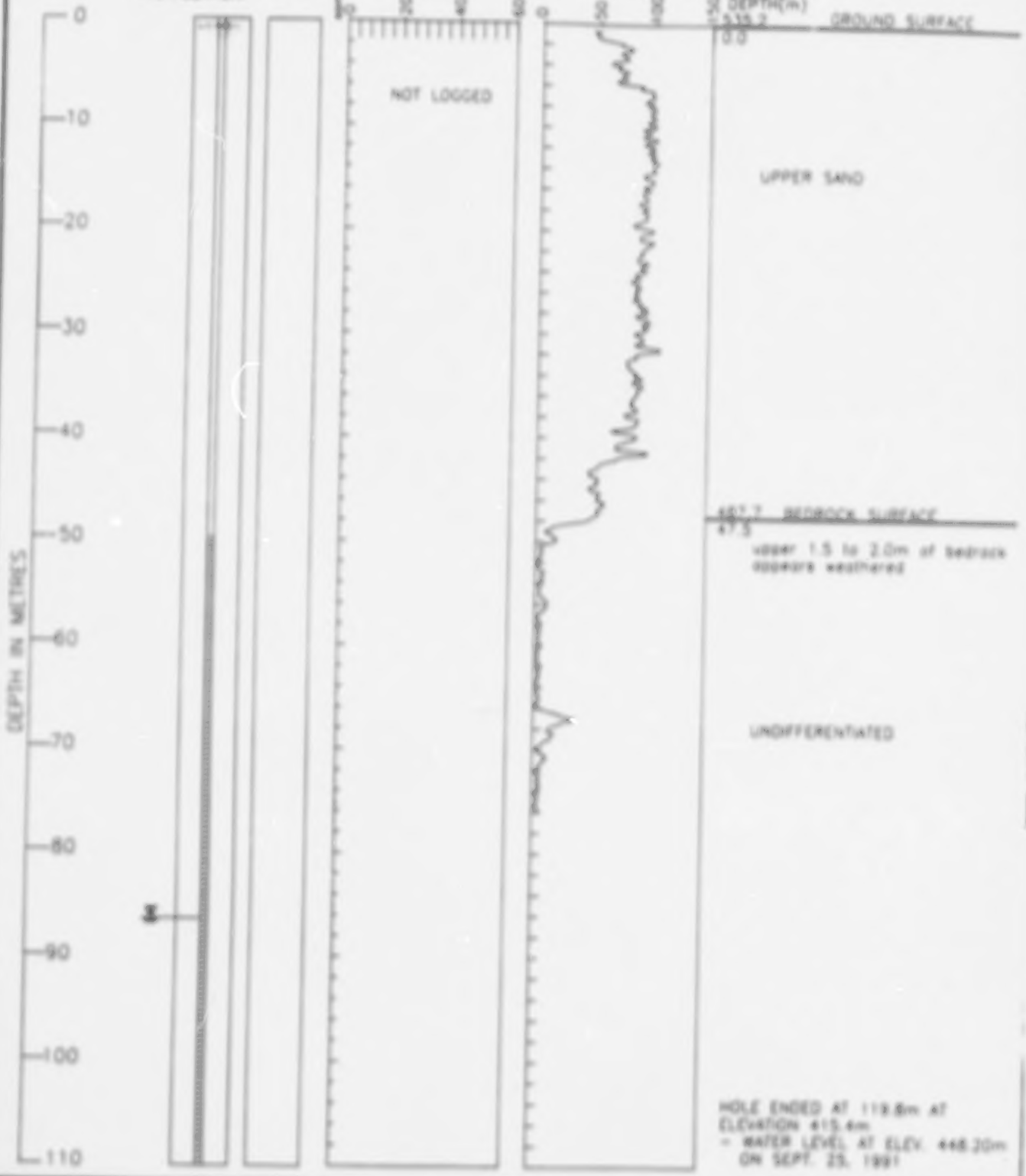
Logged RB
Checked RB

RECORD OF BOREHOLE ETW-1

Location 6850.0N 8485.0E
Datum MINE

Drilling Contractor
Drilling Method ROTARY

Dated Drilled
Date Installed



HOLE ENDED AT 119.8m AT ELEVATION 415.4m
- WATER LEVEL AT ELEV. 448.20m ON SEPT. 25, 1991

Project No. 911-1726

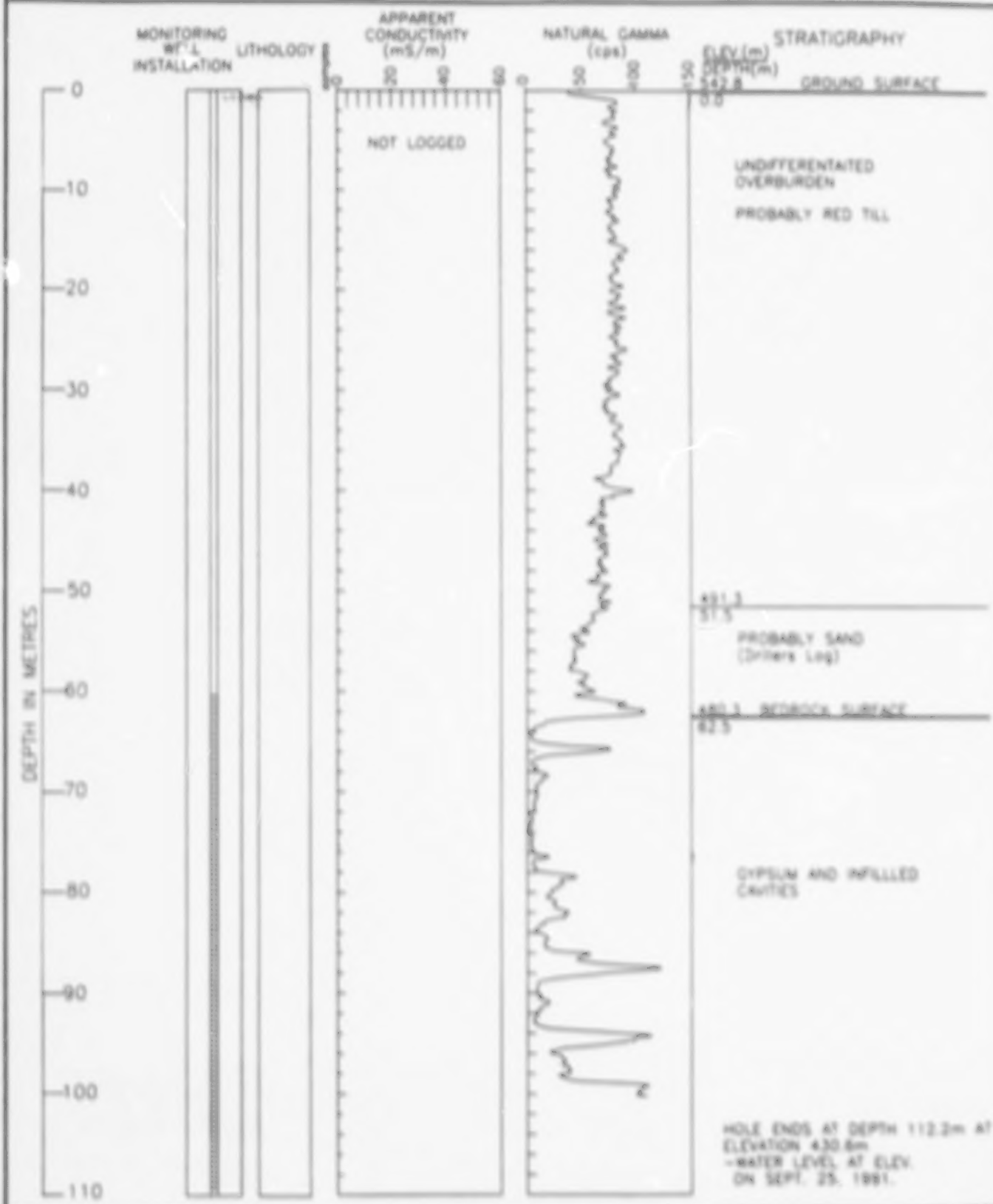
Scale 1:500

Golder Associates

Logged
Checked

RECORD OF BOREHOLE ETW-2

Location 6745.0N 8175.0E | Drilling Contractor | Dated Drilled
Datum MINE | Drilling Method ROTARY | Date Installed



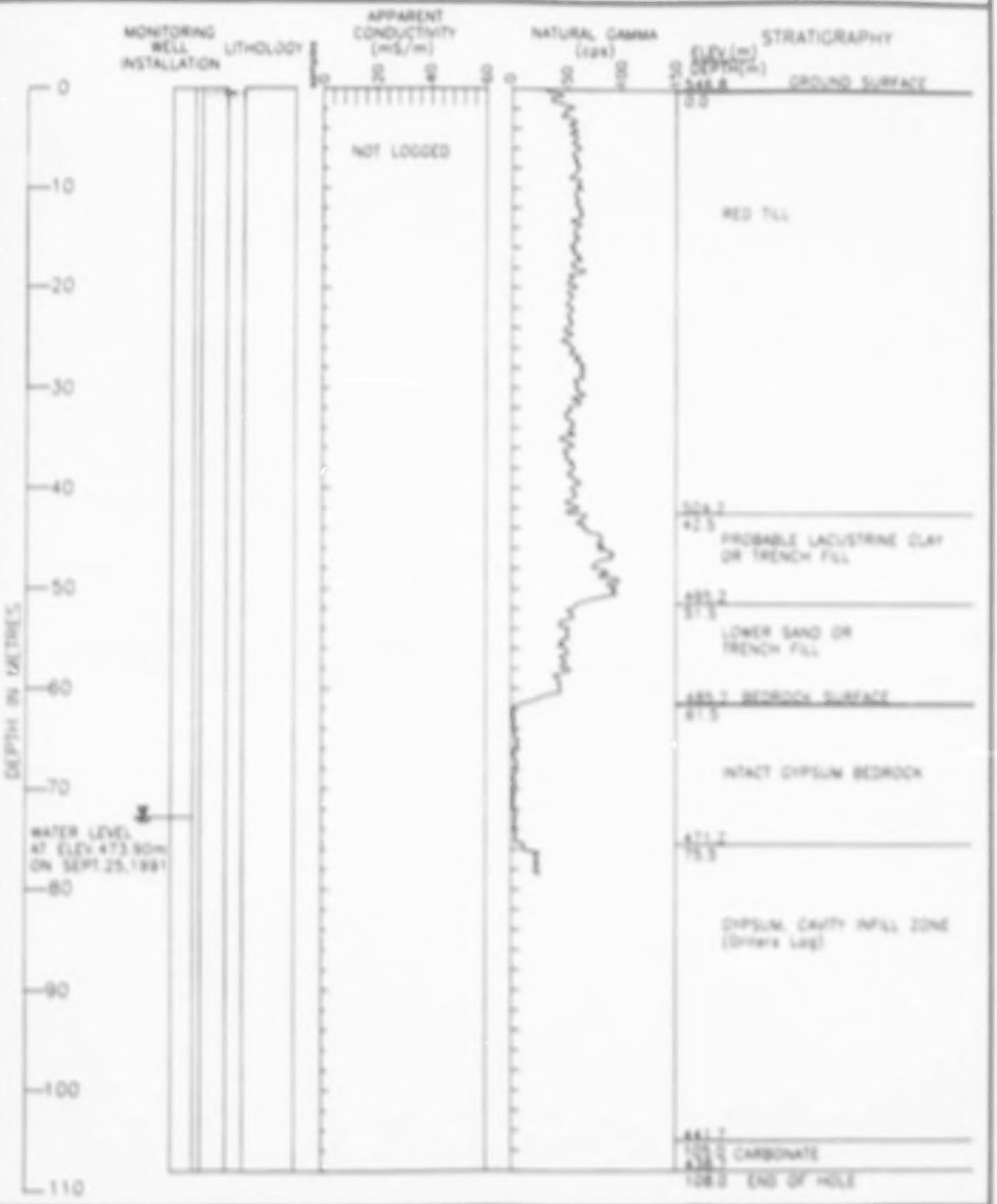
Project No. 911-1726 | Scale 1:500 | Golder Associates | Logged | Checked

RECORD OF BOREHOLE ETW-3

Location 6610.0N 7920.0E
Datum MINE

Drilling Contractor
Drilling Method ROTARY

Dated Drilled
Date Installed



Project No. 911-1726

Scale 1:500

Golder Associates

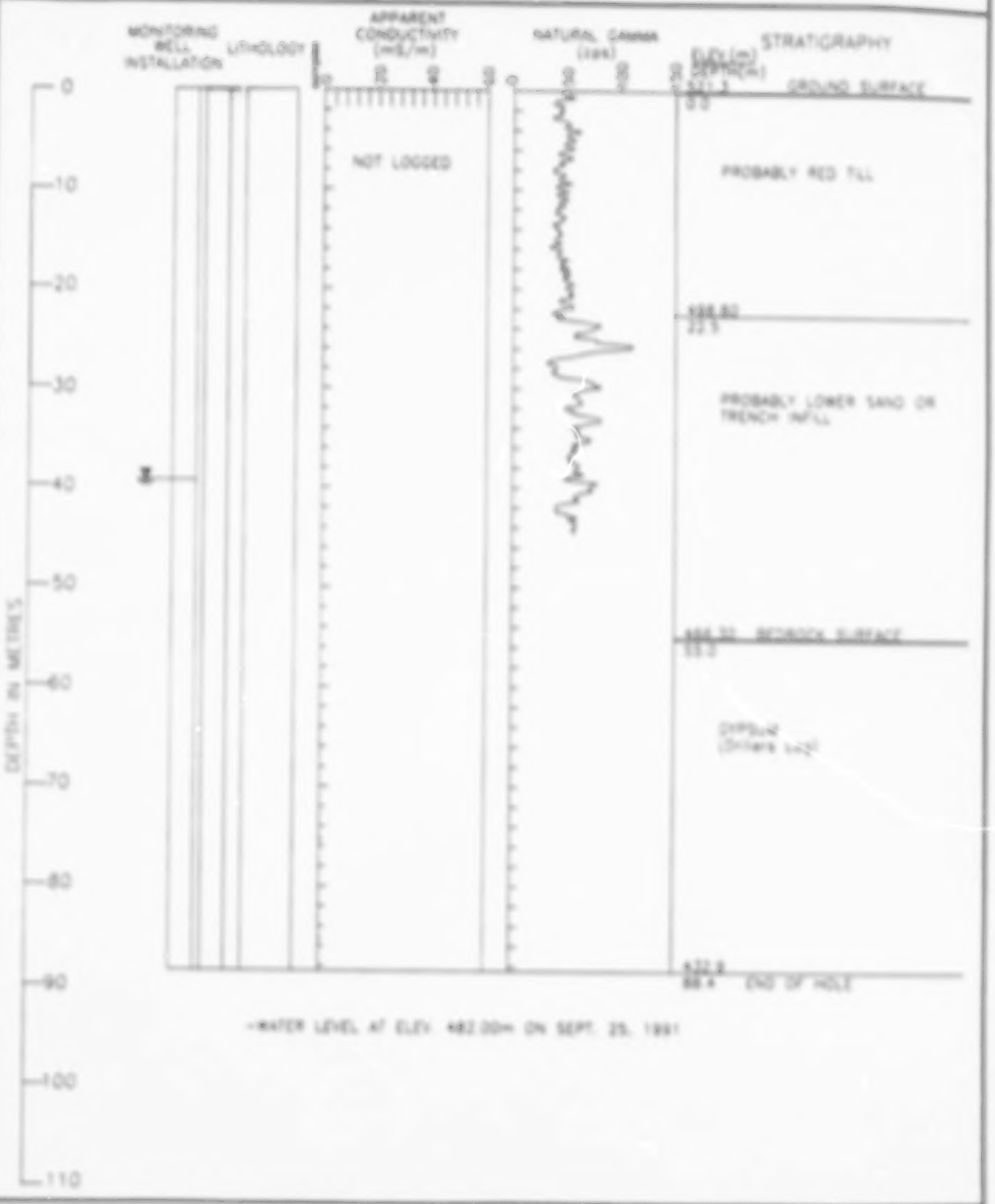
Logged
Checked

RECORD OF BOREHOLE ETW-4

Location 7810.2N 9423.3E
Datum MTM

Drilling Contractor
Drilling Method ROTARY

Dated Drilled
Date Historied



Project No. 911-1726

Scale 1:500

Golder Associates

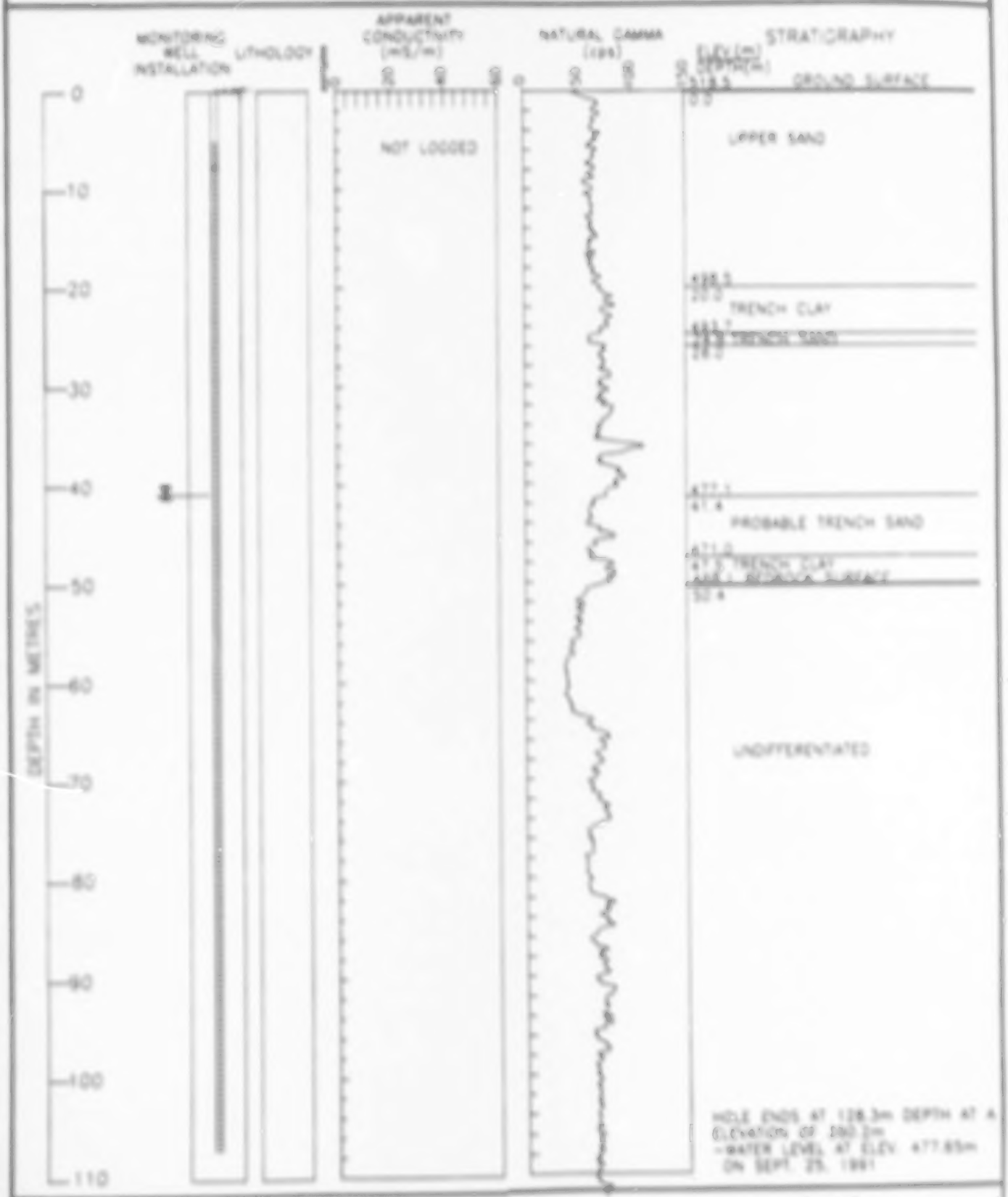
Logged
Checked

RECORD OF BOREHOLE DW-1

Location 7240.0N 9993.0E
Datum MINE

Drilling Contractor
Drilling Method ROTARY

Dated Drilled
Date Installed



Project No. 911-1726

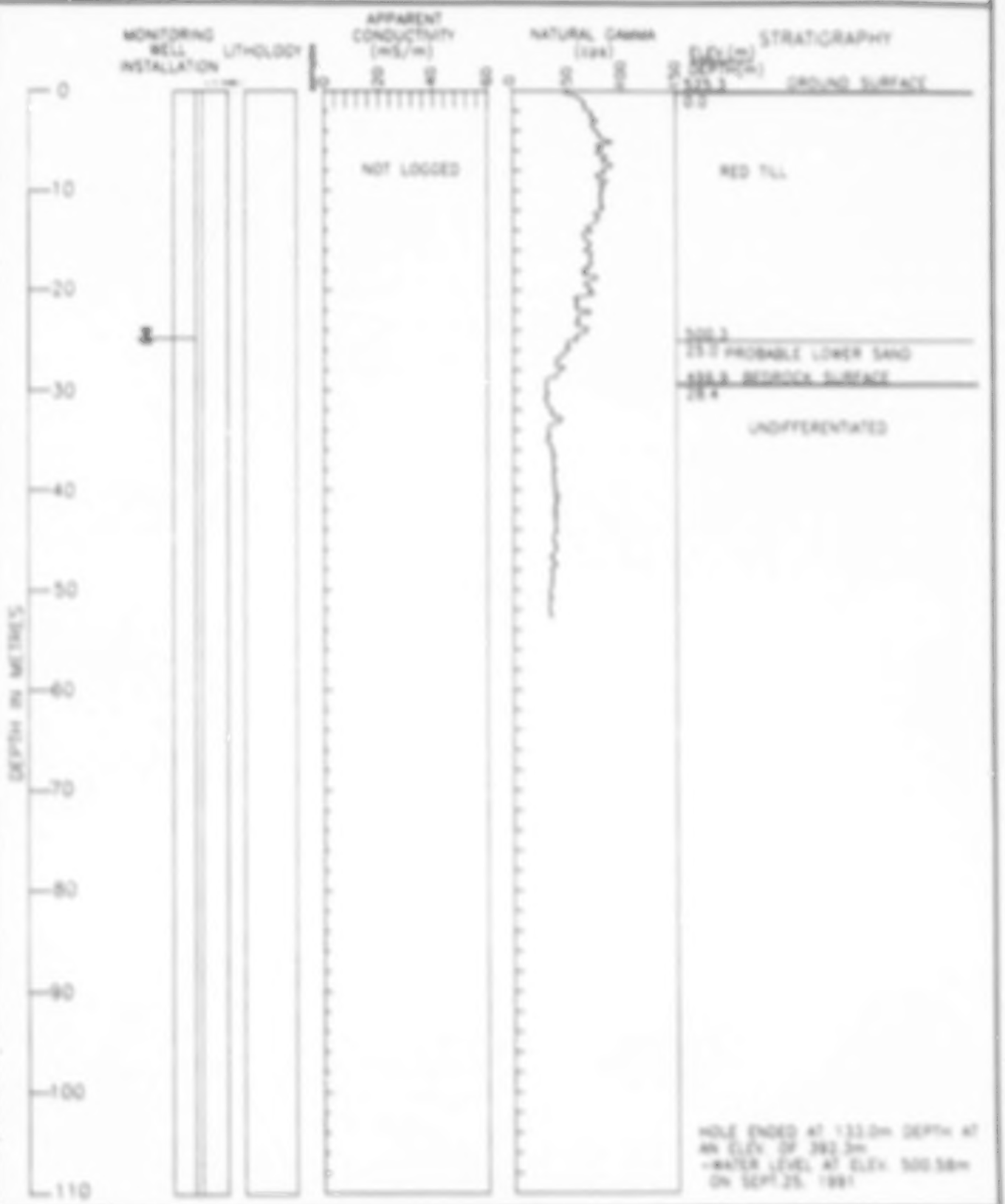
Scale 1:500

Golder Associates

Logged
Checked

RECORD OF BOREHOLE DW-2

Location 7294.01N 6891.0E | Drilling Contractor | Dates Drilled
Datum MINE | Drilling Method ROTARY | Date Installed



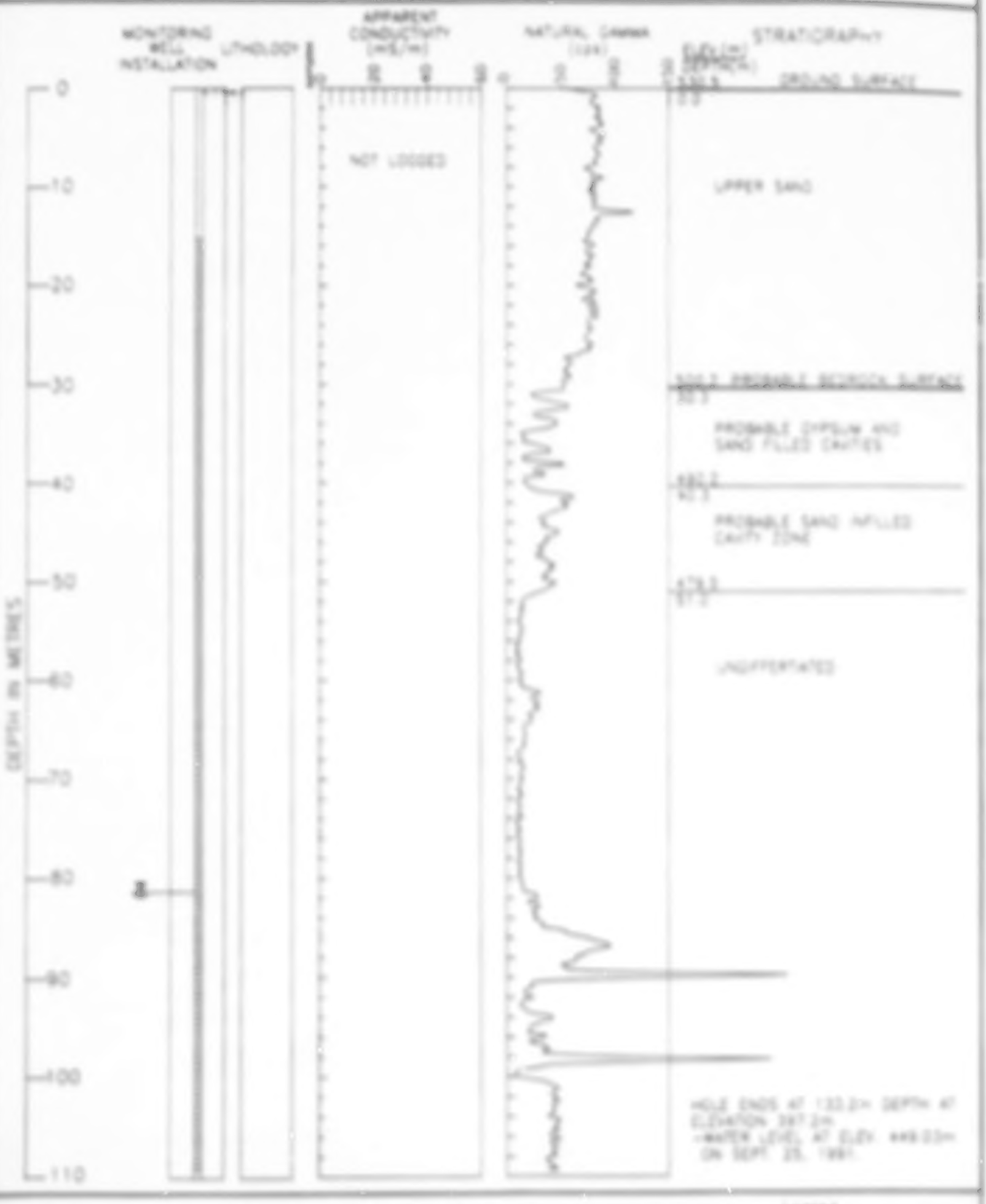
Project No. 911-1728 | Scale 1:500 | Golder Associates | Logged | Checked

RECORD OF BOREHOLE DW-3

Location 6887.2N 8540.0E
Datum MINE

Drilling Contractor
Drilling Method ROTARY

Dates Drilled
Date Finished



Project No. 911-1726

Scale 1:500

Golder Associates

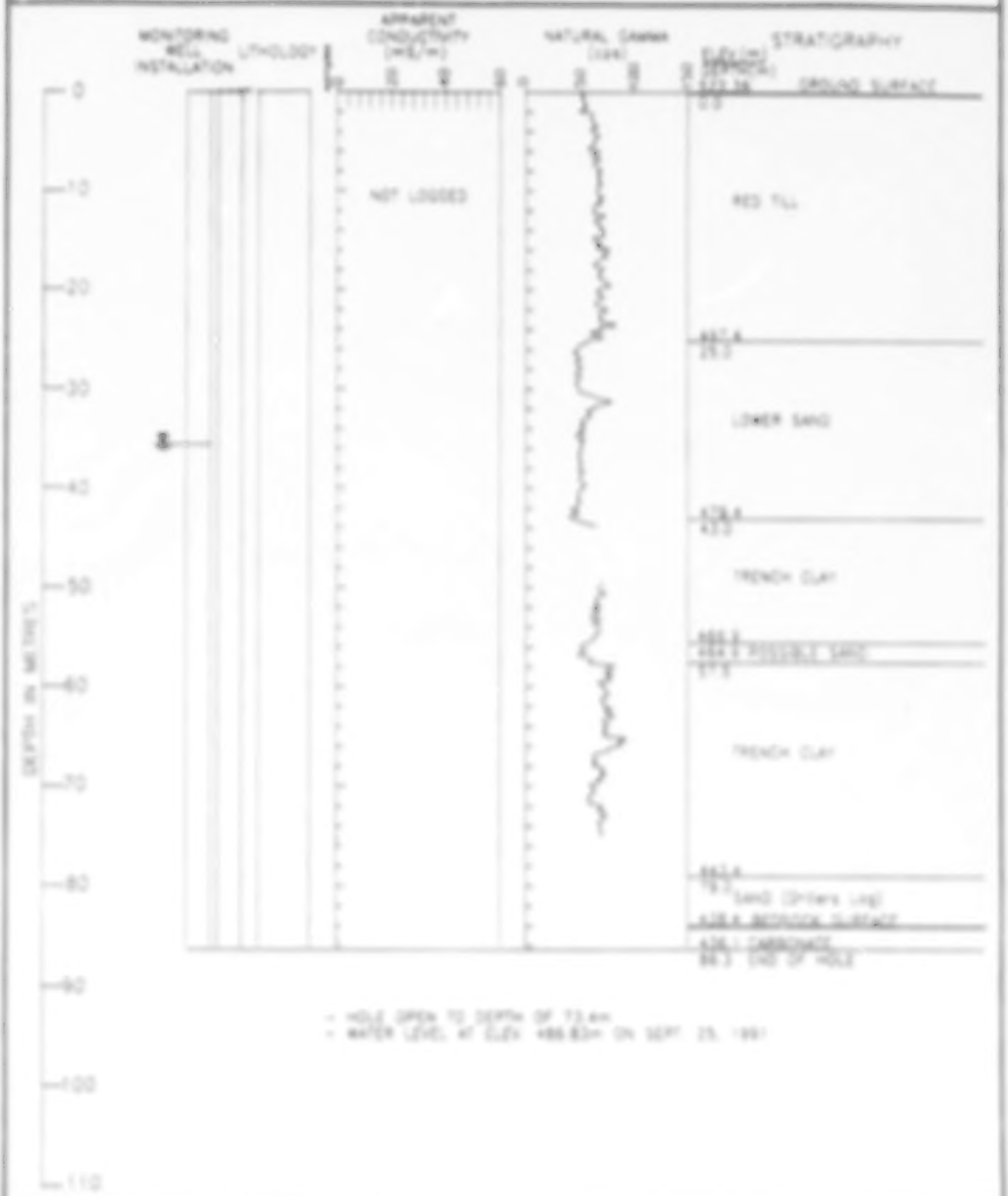
Logged
Checked

RECORD OF BOREHOLE OW-2

Location 7270.0N 8840.0E
Datum MINE

Drilling Contractor
Drilling Method ROTARY

Dates Drilled
Date Initialed



- HOLE OPEN TO DEPTH OF 73.4m
- WATER LEVEL AT ELEV 486.83m ON SEPT 25, '91

Project No. 911-1726

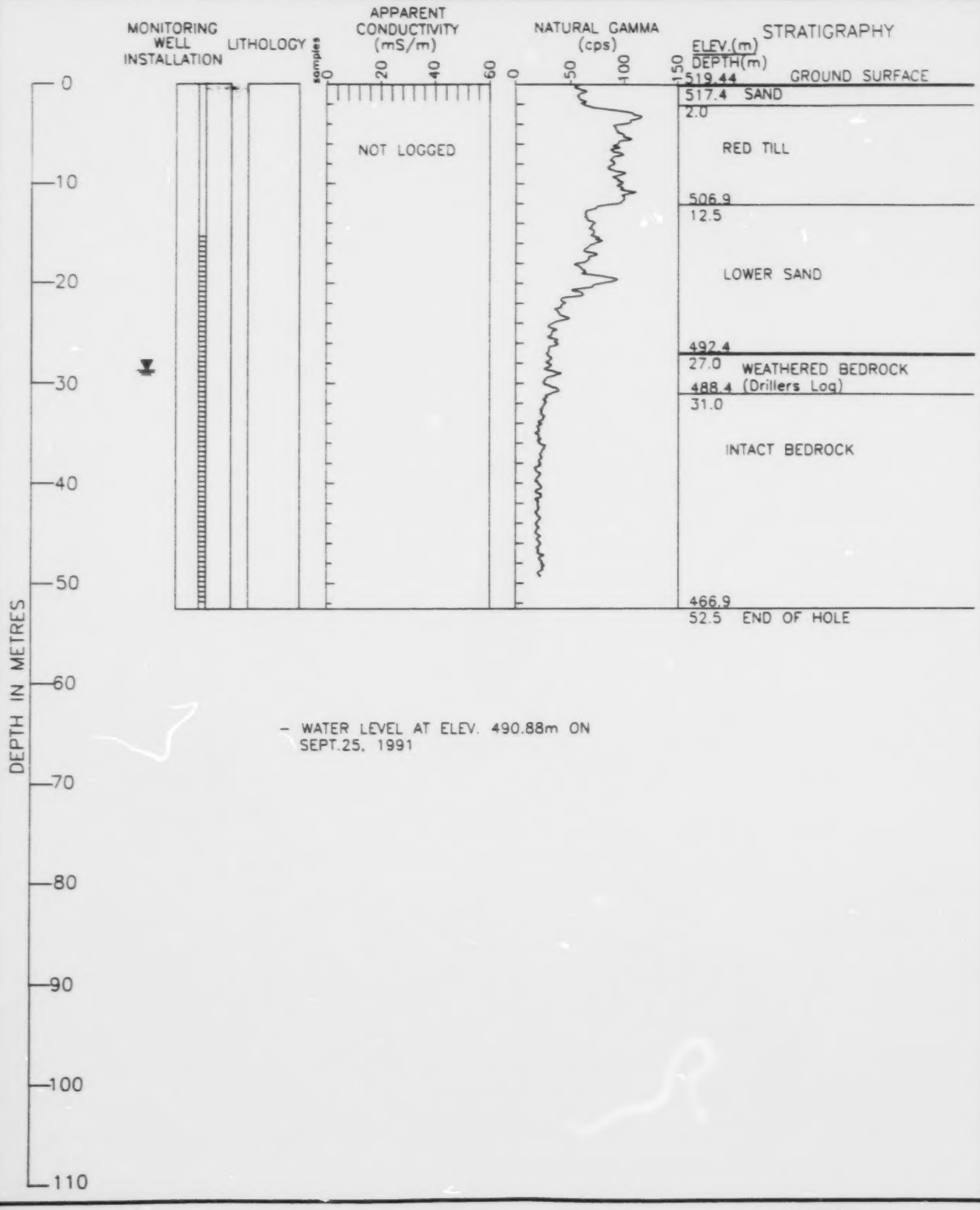
Scale 1:500

Golder Associates

Logged
Checked

RECORD OF BOREHOLE OW-3

Location 7358.0N 9071.0E | Drilling Contractor | Dated Drilled
Datum MINE | Drilling Method ROTARY | Date Installed



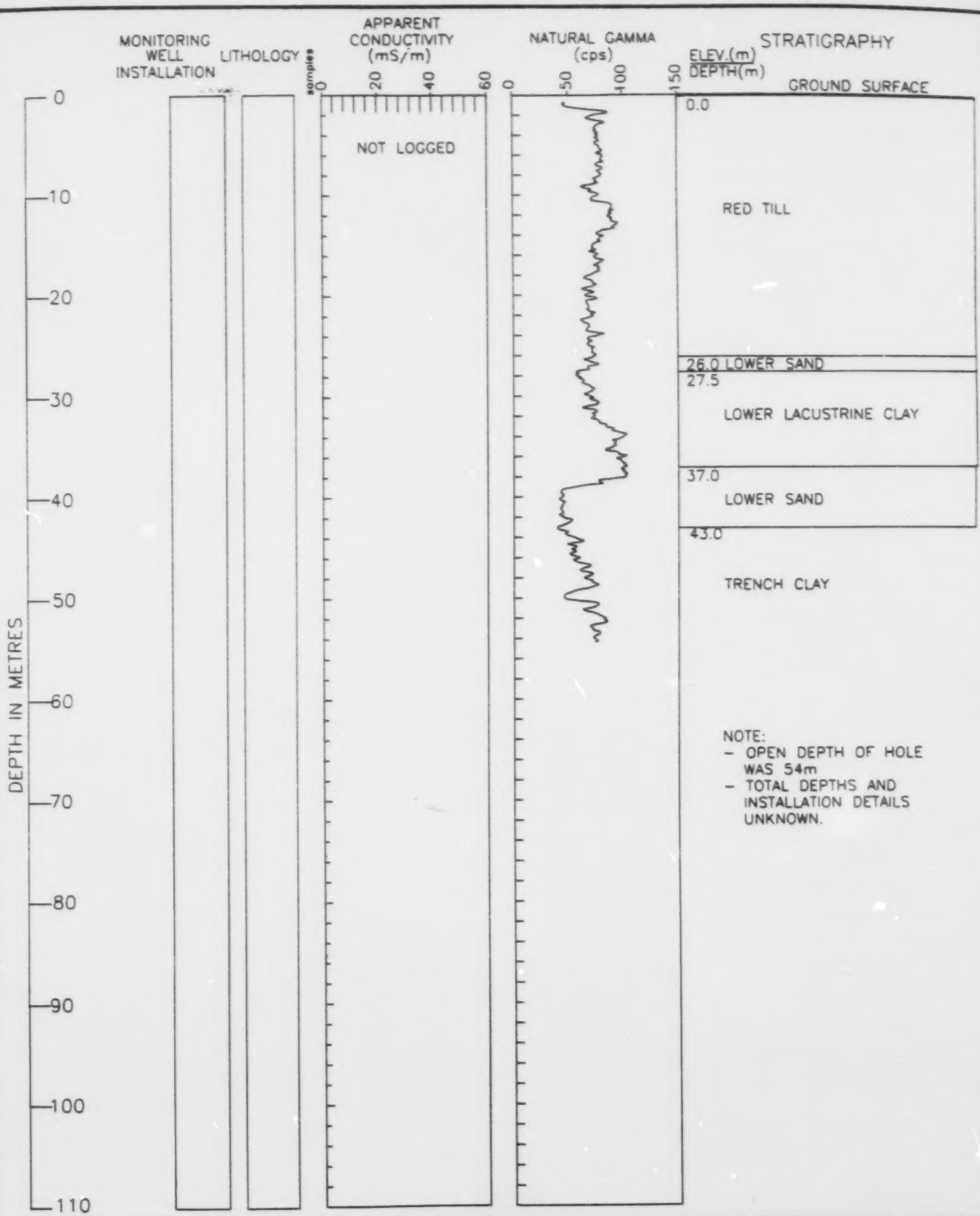
Project No. 911-1726 | Scale 1:500 | Golder Associates | Logged | Checked

RECORD OF BOREHOLE OW-4

Location 7100N 8270E
Datum MINE

Drilling Contractor
Drilling Method ROTARY

Dated Drilled
Date Installed



NOTE:
- OPEN DEPTH OF HOLE WAS 54m
- TOTAL DEPTHS AND INSTALLATION DETAILS UNKNOWN.

Project No. 911-1726

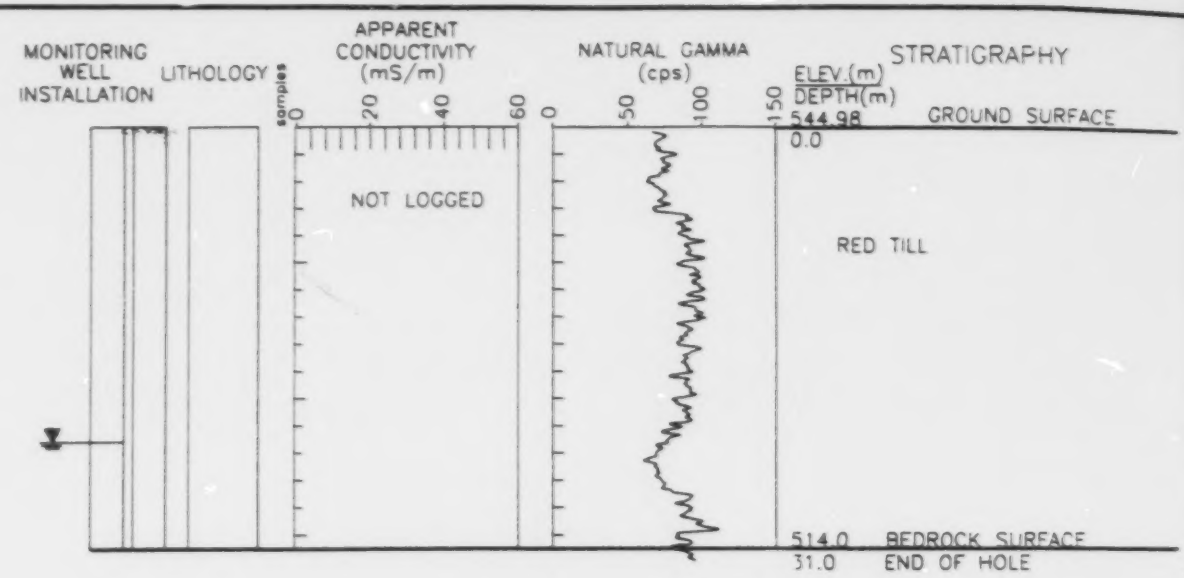
Scale 1:500

Golder Associates

Logged
Checked

RECORD OF BOREHOLE OW-6

Location 6704.0N 8337.0E | Drilling Contractor | Dated Drilled
Datum MINE | Drilling Method ROTARY | Date Installed



- WATER LEVEL AT ELEV. 521.72m ON SEPT.25, 1991

DEPTH IN METRES

0
10
20
30
40
50
60
70
80
90
100
110

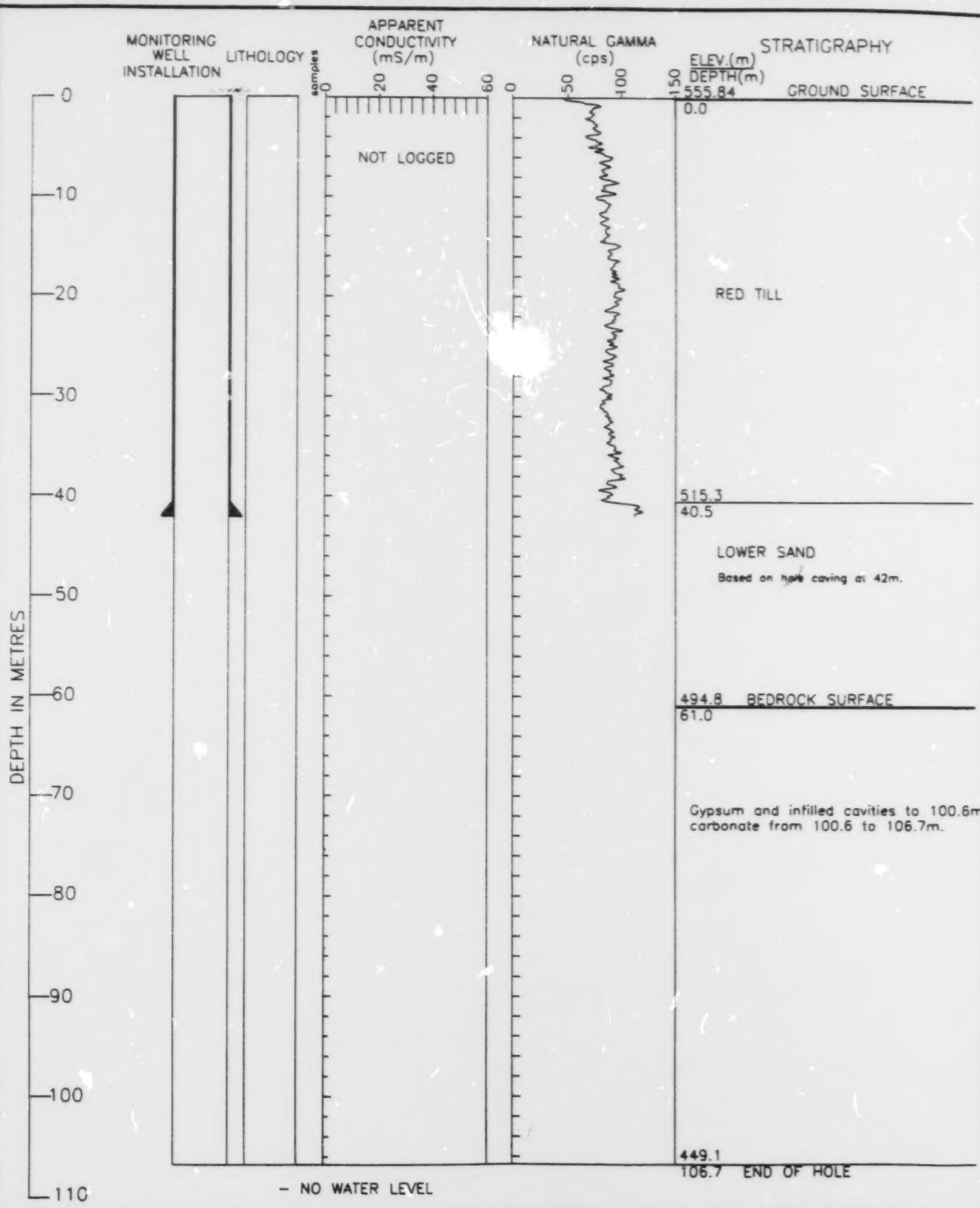
Project No. 911-1726 | Scale 1:500 | Golder Associates | Logged | Checked

RECORD OF BOREHOLE H-3

Location 6251.0N 7667.0E
Datum MINE

Drilling Contractor
Drilling Method ROTARY

Dated Drilled
Date Installed



Project No. 911-1726

Scale 1:500

Golder Associates

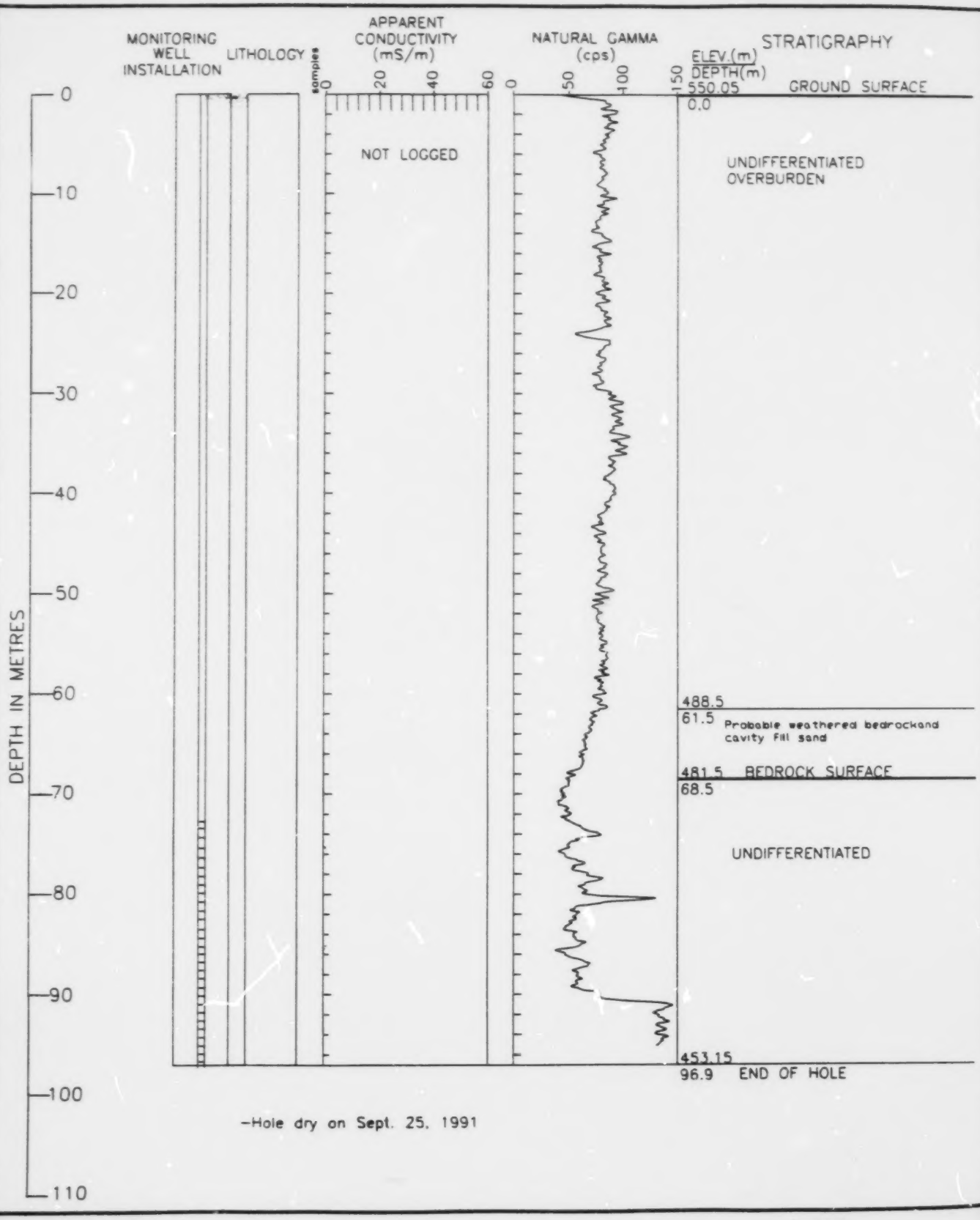
Logged
Checked

RECORD OF BOREHOLE H-4

Location 6718.0N 8043.0E
Datum MINE

Drilling Contractor
Drilling Method ROTARY

Dated Drilled
Date Installed



-Hole dry on Sept. 25, 1991

Project No. 911-1726

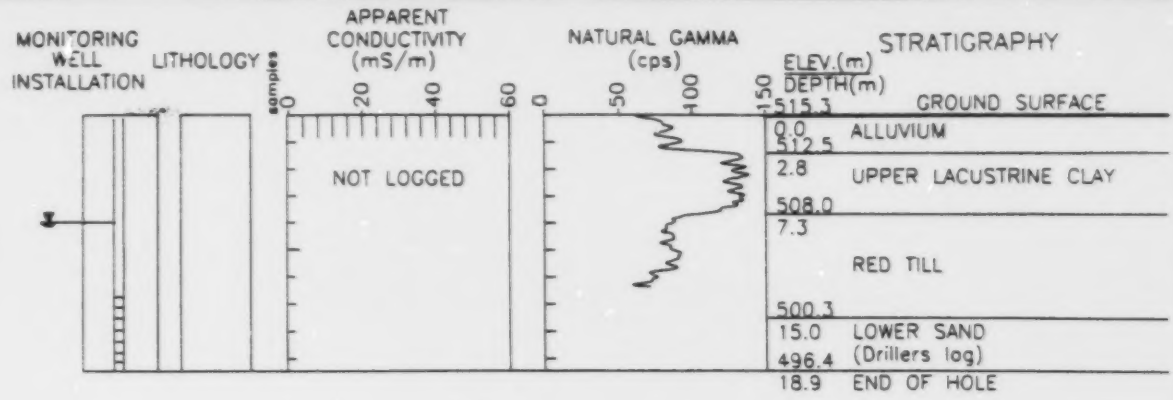
Scale 1:500

Golder Associates

Logged
Checked

RECORD OF BOREHOLE H-5

Location 7370.0N 9291.0E | Drilling Contractor | Dated Drilled
Datum MINE | Drilling Method ROTARY | Date Installed



– Water level at Elev. 507.42m on Sept. 25, 1991

DEPTH IN METRES

0
10
20
30
40
50
60
70
80
90
100
110

Project No. 911-1726 | Scale 1:500 | Golder Associates | Logged | Checked

APPENDIX C

LABORATORY SOIL TESTING

APPENDIX C - LABORATORY SOIL TESTING

Table C-1 Summary of Moisture Content of Soil Units

Table C-2 Summary of Atterberg Limits for Clayey Soil Units

Table C-3 Hydraulic Conductivity of Sandy Soils Determined by Hazen Method

Figure C-1 Grain Size Distributions - Upper Lacustrine Clay

Figure C-2 Grain Size Distribution - Upper Sand

Figure C-3 Grain Size Distribution - Red Till

Figure C-4 Grain Size Distribution Lower Lacustrine Clay

Figure C-5 Grain Size Distribution - Lower Sand

Figure C-6 Grain Size Distribution - Lower Till

Figure C-7 Grain Size Distribution - Trench Clay

Figure C-8 Grain Size Distribution - Trench Sand

Figure C-9 Grain Size Distribution and Material Description for Hanging Wall Sample from 841 West Stope

Figure C-10 Plasticity Chart - Clayey Soil Units

TABLE C-1

SUMMARY OF MOISTURE CONTENT OF SOIL UNITS

Soil Unit	No. Samples	Moisture Content %	
		Range	Average
Upper Lacustrine Clay	3	17.2-25.8	22.2
Upper Sand	9	3.7-20.0	12.1
Red Till	8	8.0-11.9	10.0
Lower Lacustrine Clay	4	15.2-23.2	17.3
Lower Sand	6	10.1-18.4	14.9
Lower Till	2	7.8-10.4	9.1
Trench Clay	5	11.4-17.8	14.7
Trench Sand	2	17.0-21.9	19.5

TABLE C-2

SUMMARY OF ATTERBERG LIMITS FOR CLAYEY SOIL UNITS

Soil Unit	Borehole No.	Sample No.	Liquid Limit	Platic Limit	Natural Water Content	Plasticity Index
Upper Lacustrine Clay	GA-3	5	40.1	20.6	23.7	19.5
	GA-12	3	35.5	20.1	17.2	15.4
Lower Lacustrine Clay	GA-6	12	33.6	17.9	15.3	15.7
	GA-27	11	27.7	18.1	15.2	9.6
Lower Till	GA-6	14	33.7	17.3	10.4	16.4
	GA-6	15	32.3	16.0	7.8	16.3
Trench Clay	GA-10	12	38.5	19.4	17.8	19.1
	GA-10	16	34.9	18.8	15.6	16.1
	GA-15	21	35.8	20.3	11.4	15.5
	Stope 101A		31.7	17.3	4.8	14.4

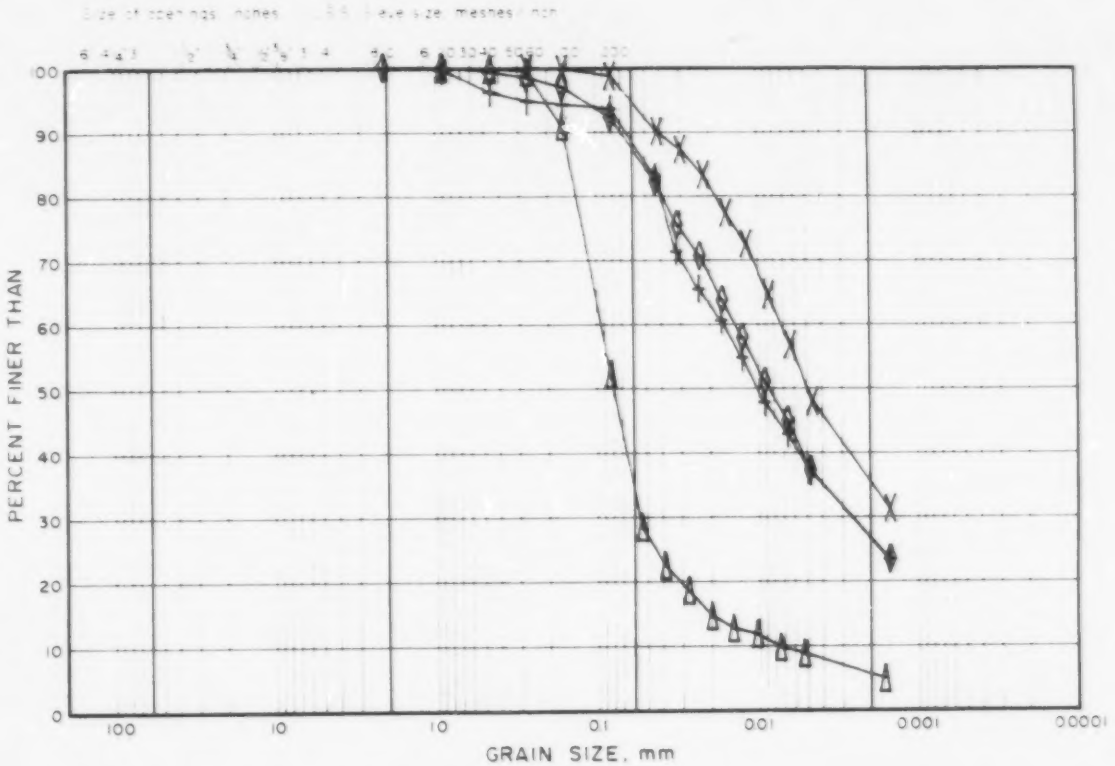
TABLE C-3

HYDRAULIC CONDUCTIVITY OF SANDY SOILS DETERMINED BY HAZEN METHOD

Soil Strata	Sample No.	D_{10} mm	K cm/sec
Upper Sand	GA-9A-1	.08	6×10^{-3}
	GA-9A-3	.08	6×10^{-3}
	GA-10A-3	.02	4×10^{-4}
	GA-10A-7	.02	4×10^{-4}
	GA-14A-3	.04	2×10^{-3}
	GA-14A-5	.008	6×10^{-5}
	GA-15-9	.04	2×10^{-3}
	GA-20-2	.07	5×10^{-5}
Lower Sand	GA-6-11	.13	2×10^{-2}
	GA-12-10	.06	4×10^{-3}
	GA-17-7	.003	9×10^{-6}
	GA-18-8A	.06	4×10^{-3}
	GA-27-10	.07	5×10^{-3}
Trench Sand	GA-15-14	.6	4×10^{-1}
	GA-27-15	.05	3×10^{-3}

GRAIN SIZE DISTRIBUTION	FIGURE C-1

UPPER LACUSTRINE CLAY



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

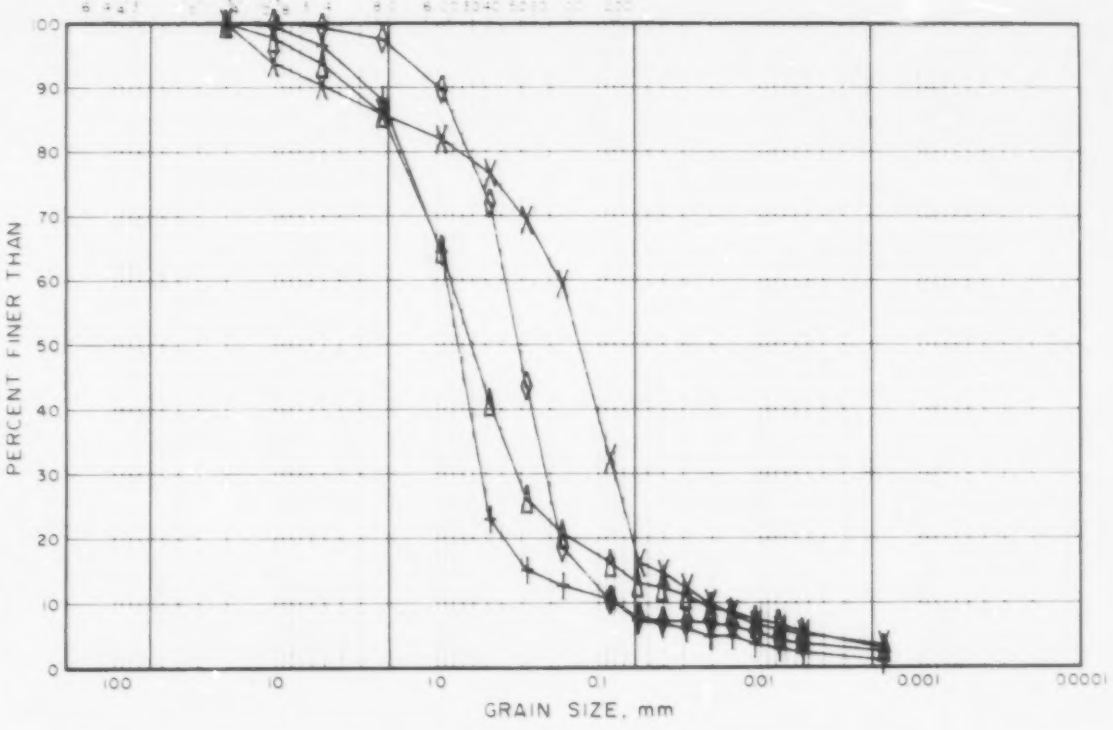
SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-3	5	6.8
◊	GA-12	3	3.6
Δ	GA-15	5A	6.8
X	GA-15	5B	6.8

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GRAIN SIZE DISTRIBUTION	FIGURE C-2

UPPER SAND



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-9A	1	2.2
◊	GA-9A	3	5.2
Δ	GA-10A	3	5.0
X	GA-10A	7	11.4

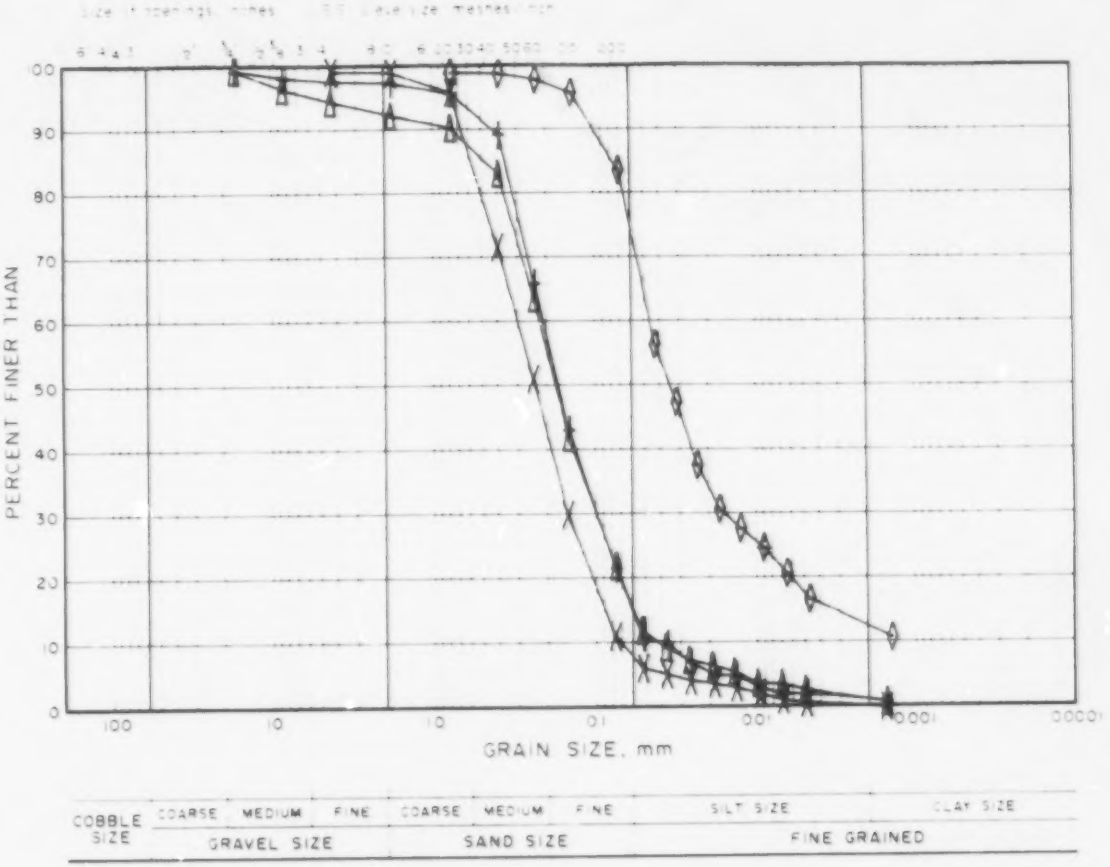
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GRAIN SIZE DISTRIBUTION

FIGURE C-2 cont'd

UPPER SAND CONT'D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-14A	3	3.7
◊	GA-14A	5	6.8
Δ	GA-15	9	12.3
X	GA-20	2	3.7

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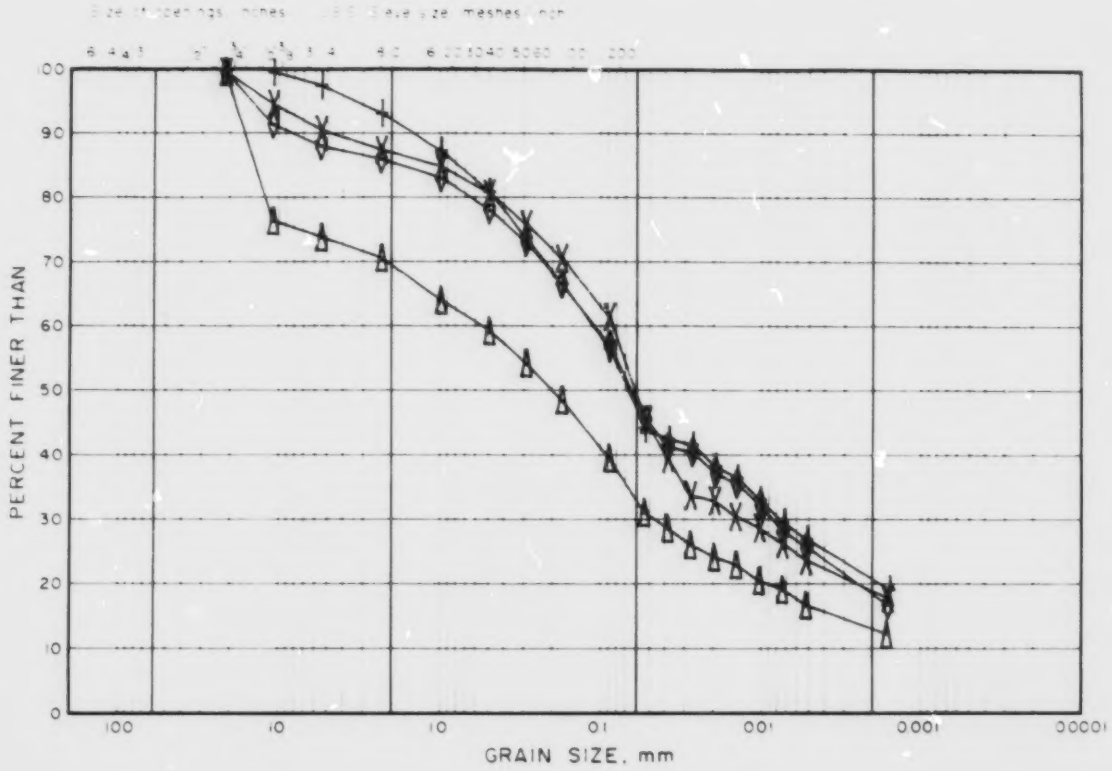
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FORM PRODUCED MAY 1985
Form GA - C-1 (Imperial)

GRAIN SIZE DISTRIBUTION

FIGURE C-3

RED TILL



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-1A	2	12.8
◊	GA-2	5A	6.5
Δ	GA-6	9	20.5
X	GA-12	7	12.8

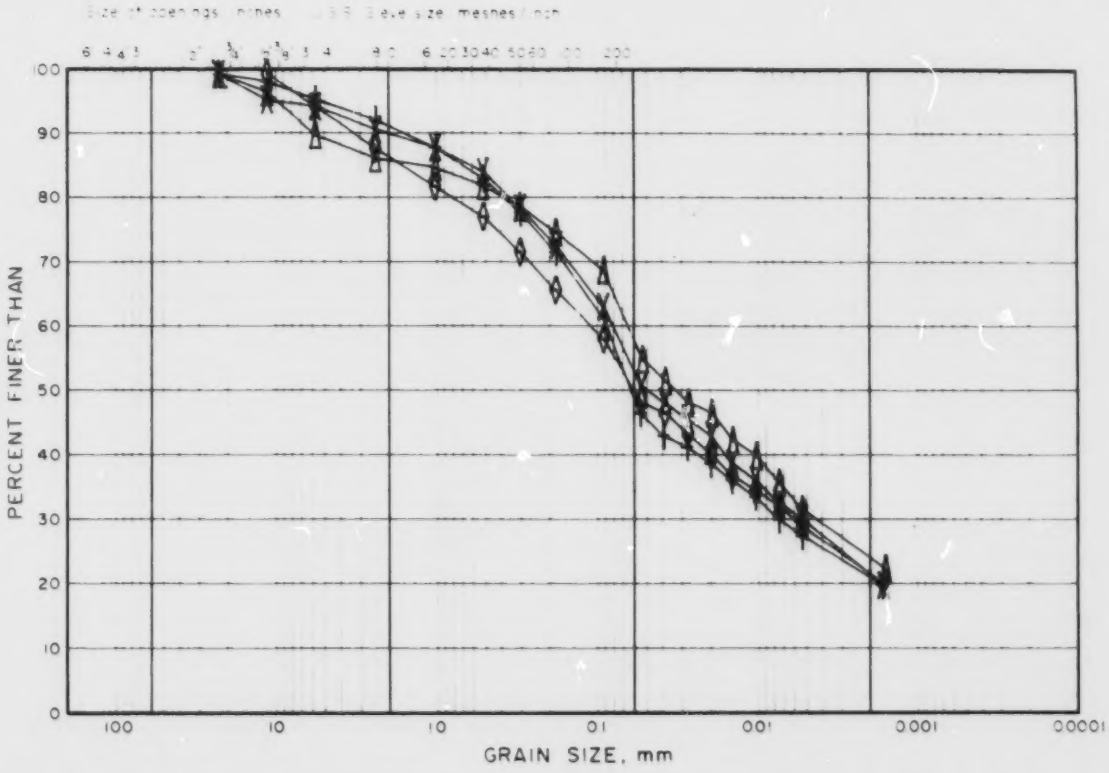
Project 911-1726

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GRAIN SIZE DISTRIBUTION

FIGURE C-3
cont'd

RED TILL CONT'D



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-14A	7	9.7
◊	GA-15	11A	18.5
Δ	GA-17	3	9.9
X	GA-27	3	5.2

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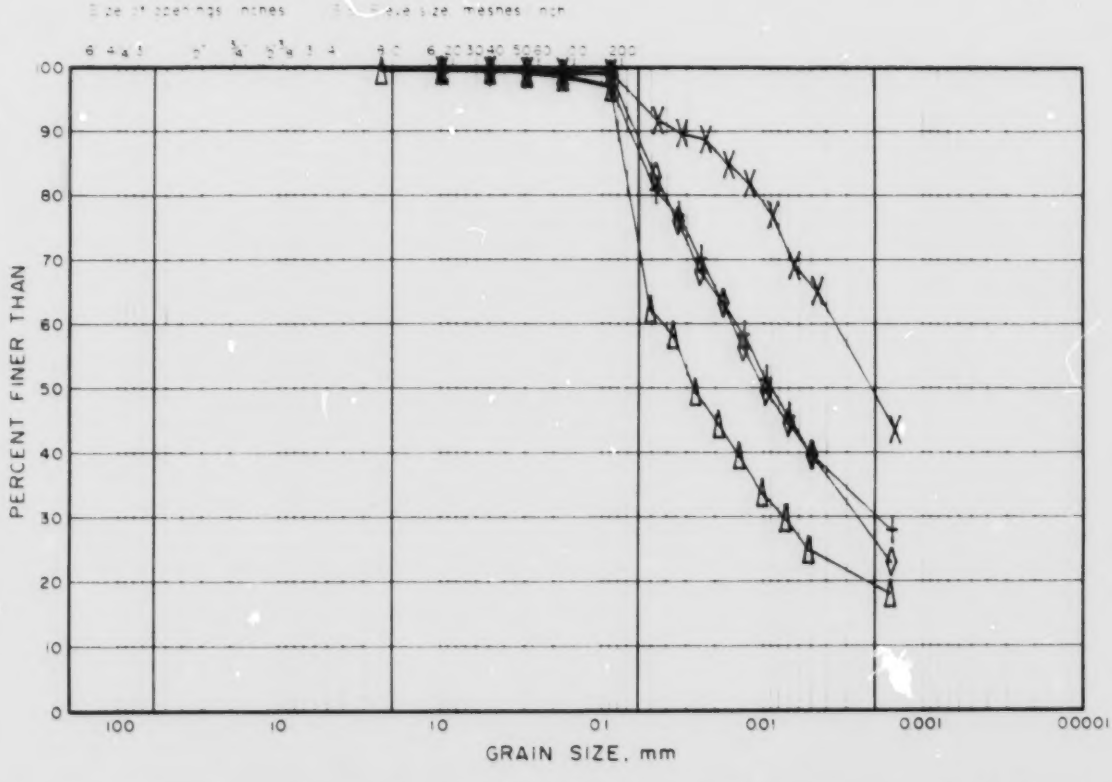
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FORM PRODUCED MAY 1986
Form GA-C-1 (Imperial)

GRAIN SIZE DISTRIBUTION

FIGURE C-4

LOWER LACUSTRINE CLAY



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-6	12	34.3
◊	GA-12	8	15.9
Δ	GA-27	11	23.6
X	GA-27	14	32.9

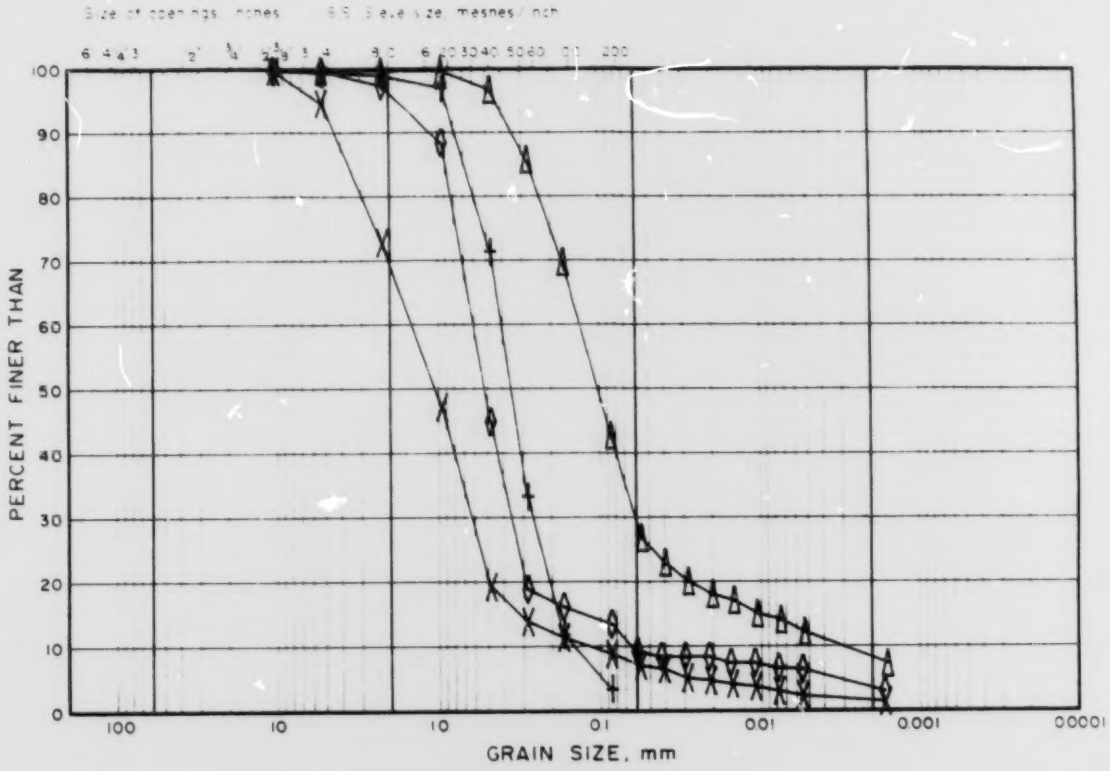
Project 911-1726

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE C-5

LOWER SAND



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-6	11	29.2
◊	GA-12	10	23.0
Δ	GA-17	7	24.9
X	GA-18	8A	17.1

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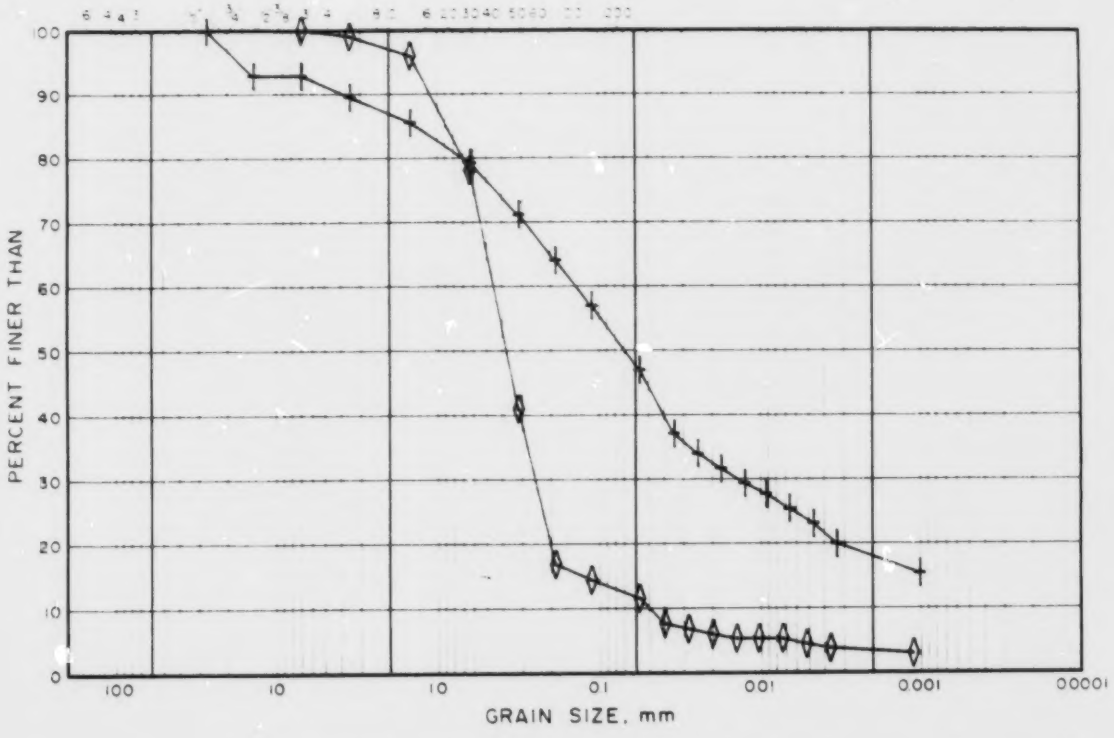
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FORM PRODUCED MAY 1986
Form GA - Golder Imperial

GRAIN SIZE DISTRIBUTION

FIGURE C-5 cont'd

LOWER SAND CONT'D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-27	9	19.0
◊	GA-27	10	20.3

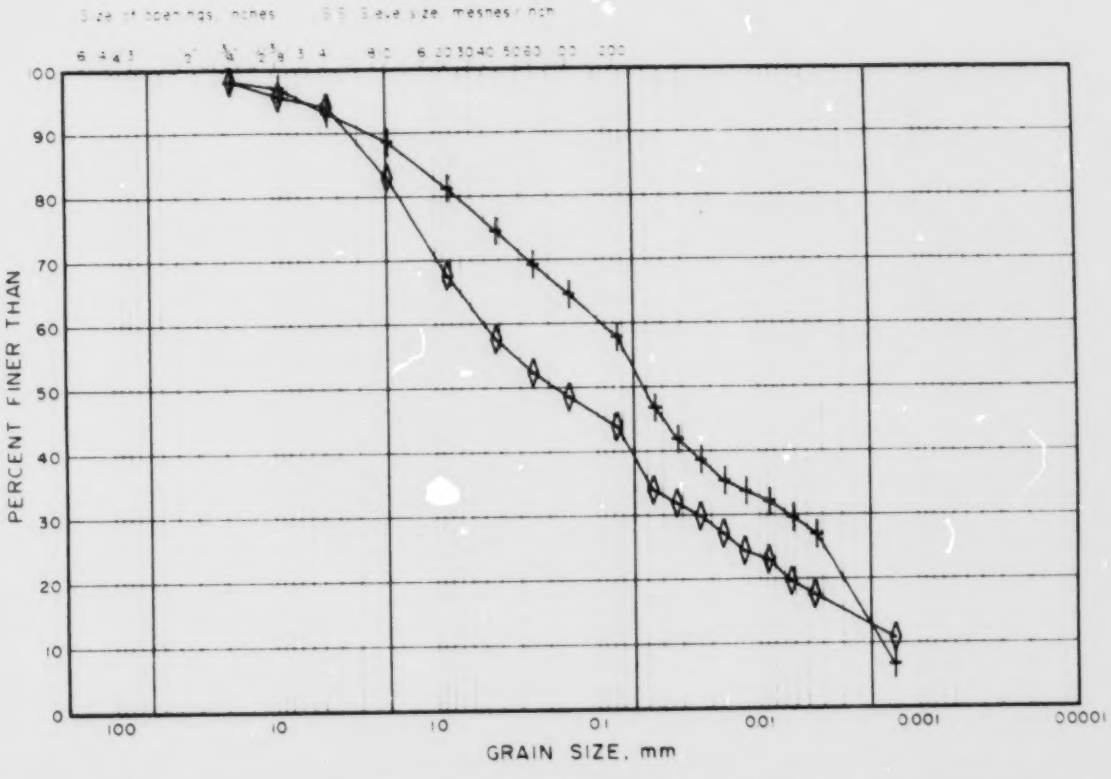
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GRAIN SIZE DISTRIBUTION

FIGURE C-6

LOWER TILL



LEGEND			
SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-6	14	40.3
◊	GA-6	15	43.2

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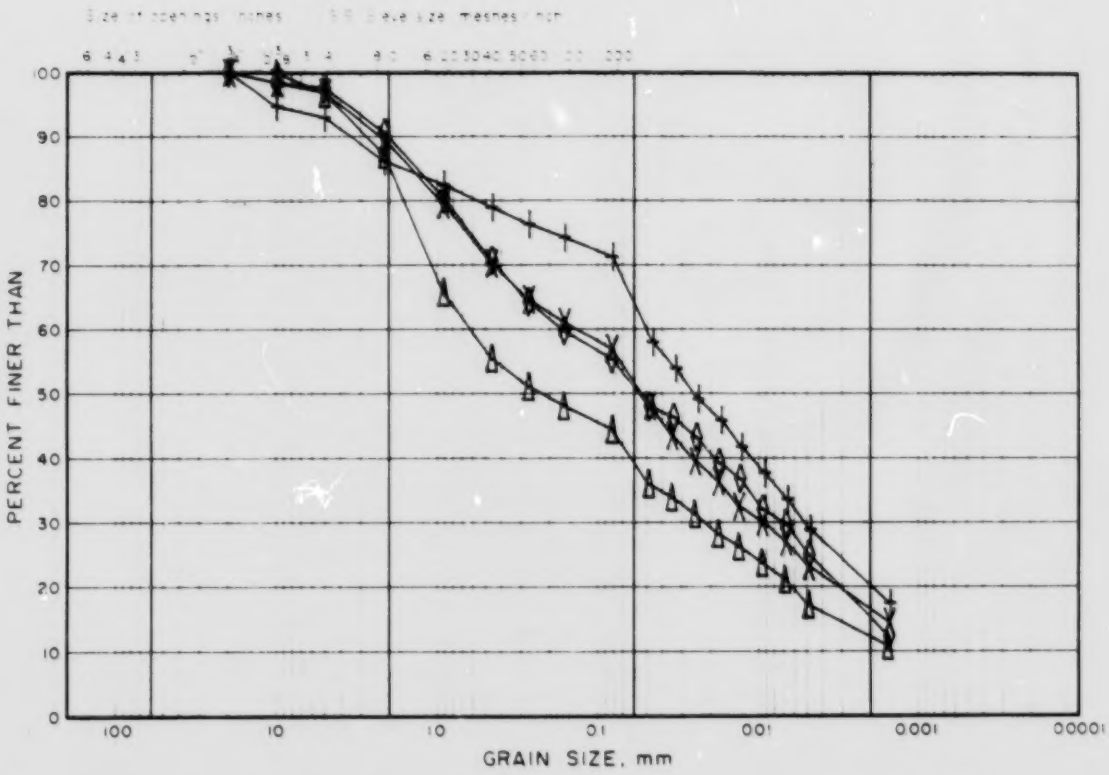
Golder Associates

FORM PRODUCED MAY 1988
Form GA-C-1 (Imperial)

GRAIN SIZE DISTRIBUTION

FIGURE C-7

TRENCH CLAY



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-10A	12	20.0
◊	GA-10A	16	38.3
Δ	GA-15	21	40.2
X	GA-15	24	49.4

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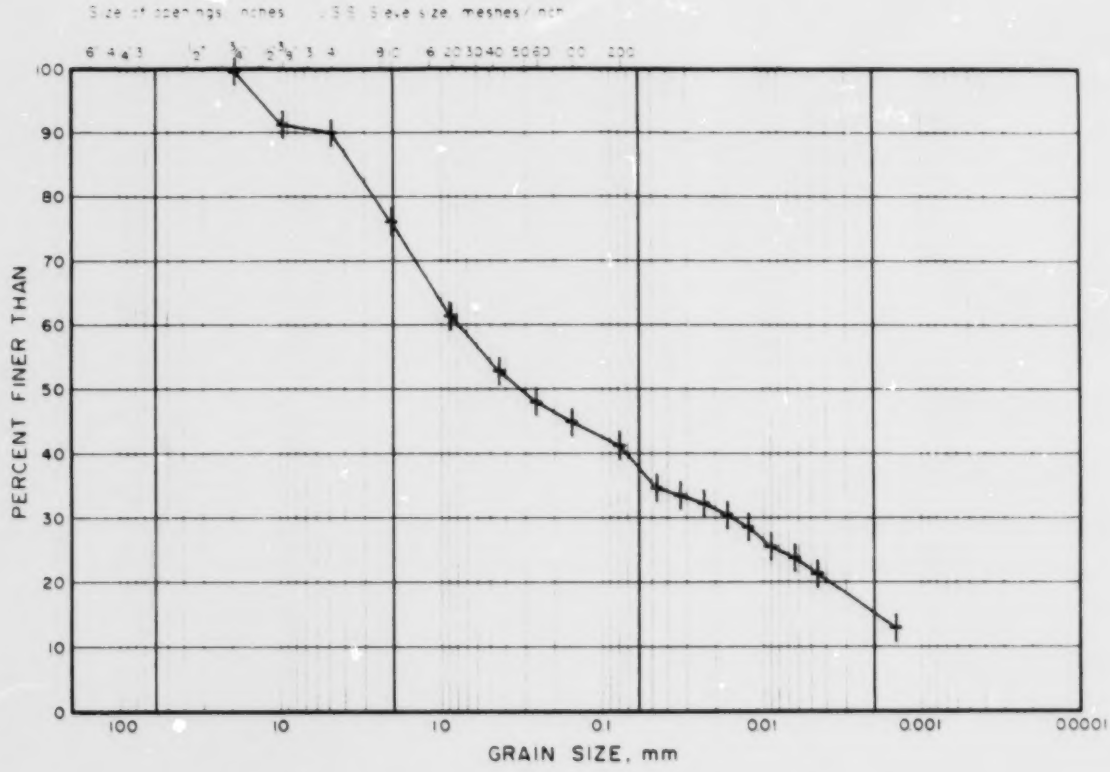
Golder Associates

FORM PRODUCED MAY 1984
FORM GA - Cal (Imperial)

GRAIN SIZE DISTRIBUTION

FIGURE C-7
cont'd

TRENCH CLAY CONT'D



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-22A	10	27.9

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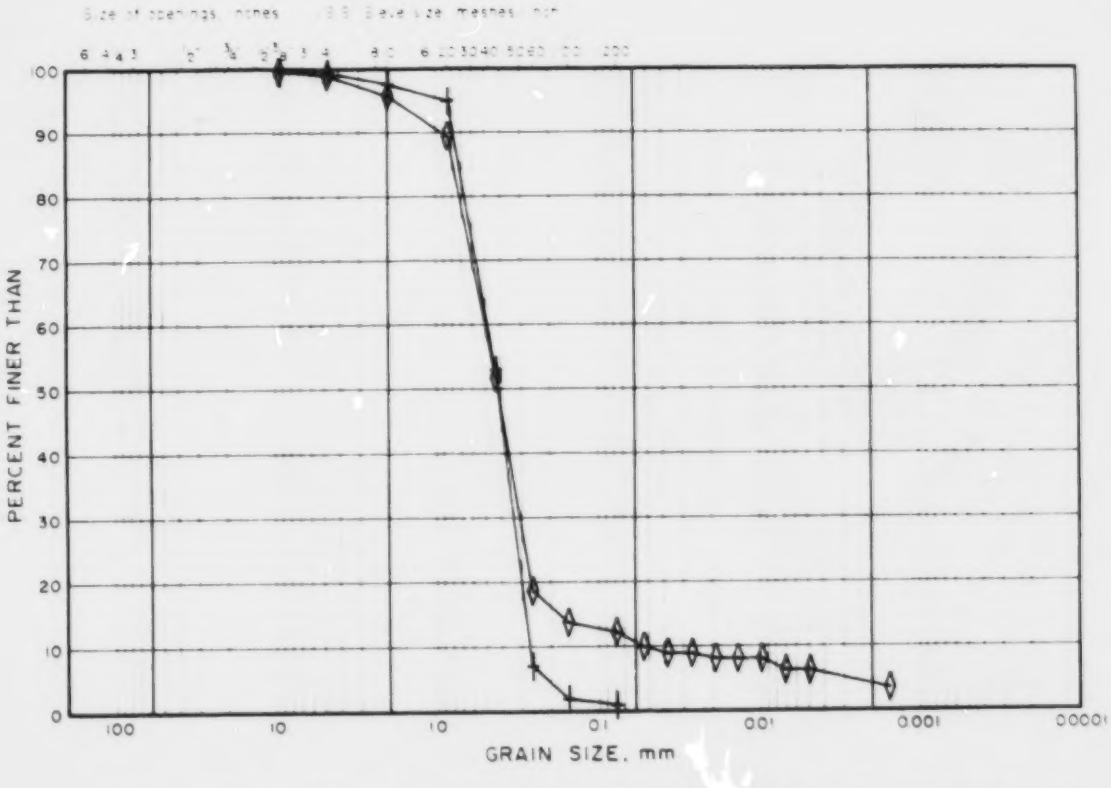
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FORM PRODUCED MAY 1985

GRAIN SIZE DISTRIBUTION

FIGURE C-8

TRENCH SAND



LEGEND

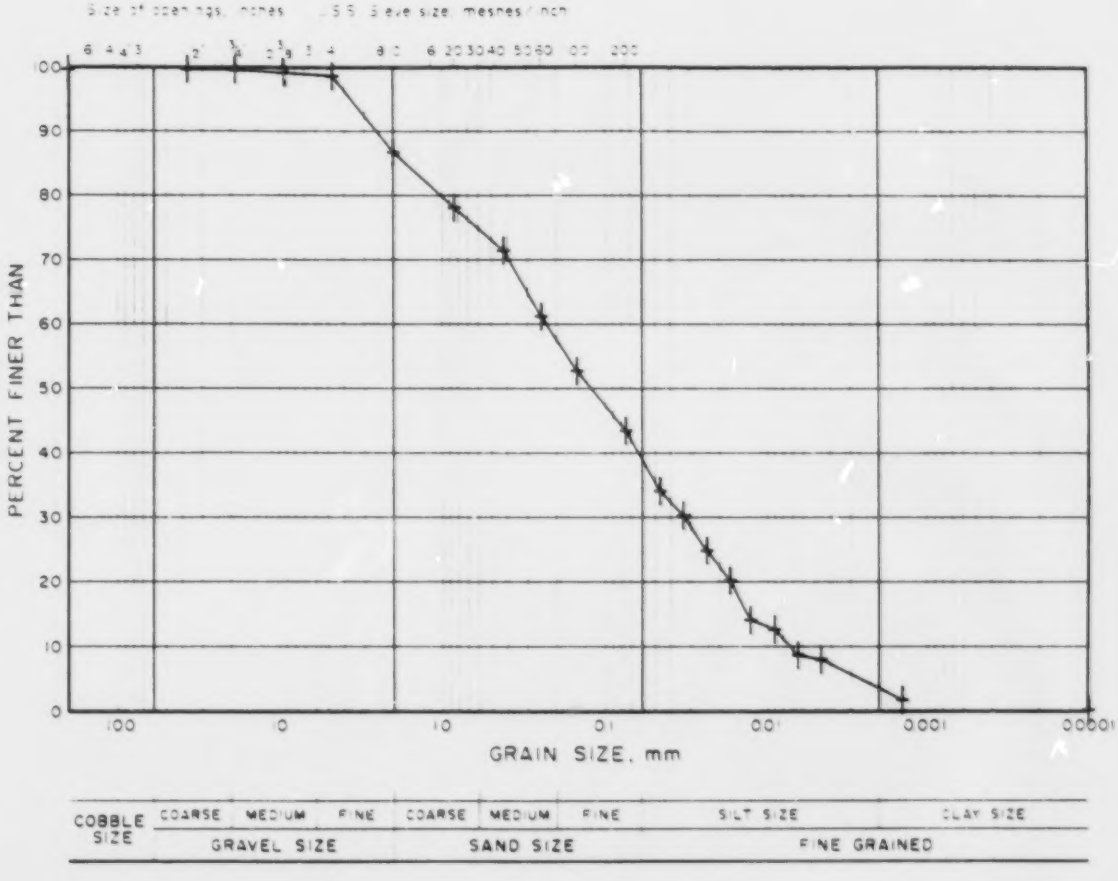
SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
+	GA-15	14	28.0
◊	GA-27	15	35.4

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GRAIN SIZE DISTRIBUTION AND MATERIAL DESCRIPTION FOR TRENCH SAMPLE FROM 841 WEST STOPE

FIGURE C-9

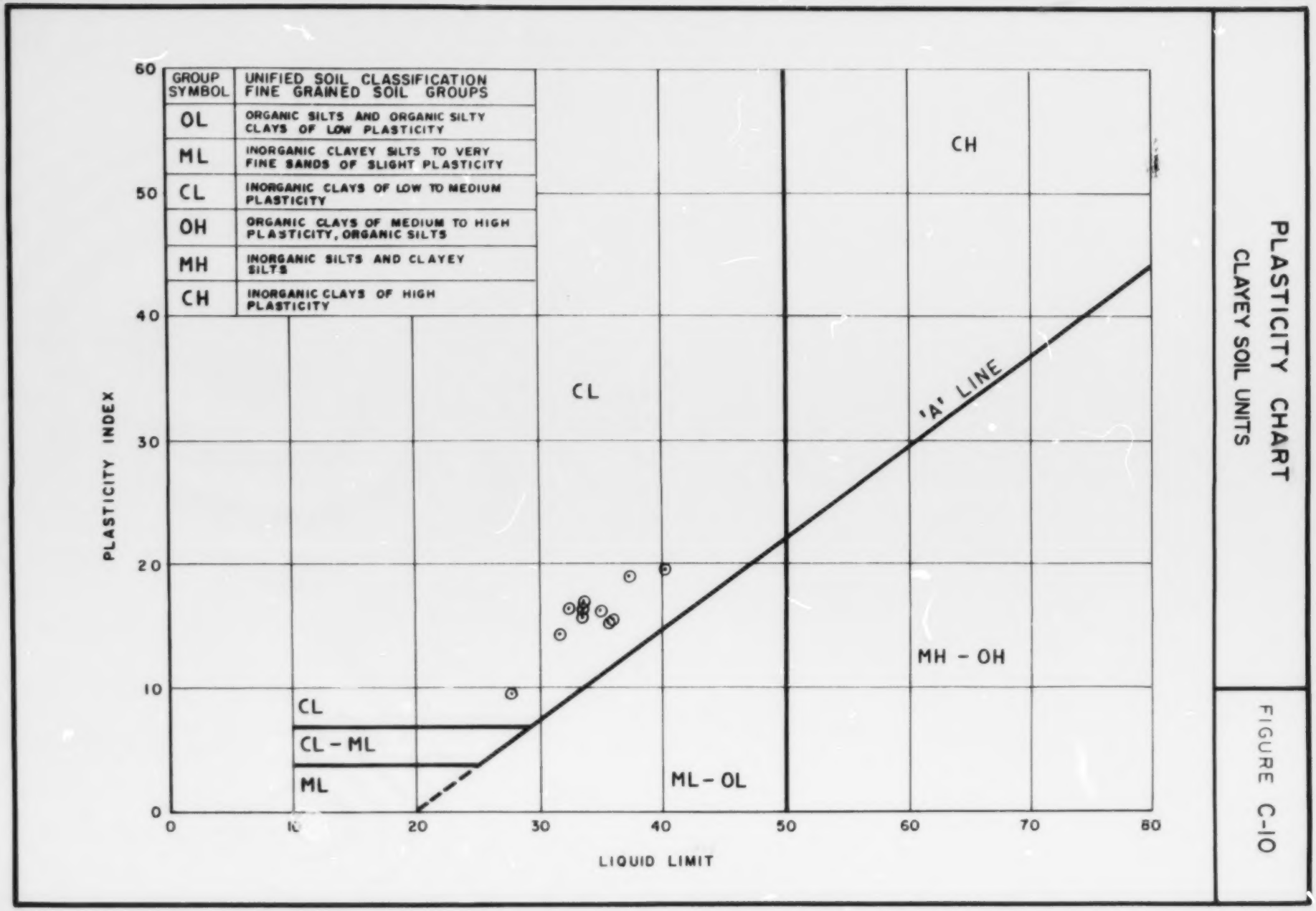


Well graded silt and sand with some gravel
Optimum dry density 126 lbs/ft^3
Optimum moisture content 4%

Liquid limit 22.8%
Plastic limit 20.6%
Plastic index 2.2%
] - for fine fraction

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PLASTICITY CHART
CLAYEY SOIL UNITS

FIGURE C-10

APPENDIX D

GROUNDWATER LEVEL MONITORING

Table D-1	Summary of Groundwater Level Monitoring Piezometers - Golder Associates Boreholes - 1991
Table D-2	Groundwater Elevations Golder Associates Piezometers - 1991
Table D-3	Groundwater Elevations Pre-Existing Monitoring Wells - 1991
Table D-4	Groundwater Elevation Underground Monitoring Locations - 1991
Following Tables:	Graphs of Groundwater Elevations Figures D-1 to D-50

TABLE D - 1
SUMMARY OF GROUNDWATER LEVEL MONITORING PIEZOMETERS
GOLDER ASSOCIATES BOREHOLES - 1991

PIEZOMETER	MINE GRID LOCATION (m) NORTHING	EASTING	GROUND SURFACE ELEV (m) *	REFERENCE ELEV (m) *	STRATIGRAPHIC MONITORING HORIZON	REMARKS
GA - 1B-1	7025.329	9670.874	518.349	518.729	red till	dry
GA - 1A1-1	7026.479	9669.337	518.312	518.755	lower sand - bedrock surface	
GA - 1A-2	7026.479	9669.337	518.312	518.755	red till	
GA - 2-1	6441.550	9391.719	519.537	520.037	red till - lower sand	
GA - 2-2	6441.550	9391.719	519.537	520.037	red till	
GA - 3-1	6697.544	9155.741	523.739	524.459	upper sand	
GA - 3-2	6697.544	9155.741	523.739	524.459	surface fill	
GA - 4-1	7138.437	8441.968	516.960	517.534	upper sand - bedrock surface	dry
GA - 5-1	7017.353	8321.728	534.860	535.404	upper sand - bedrock surface	
GA - 6-1	6973.085	8149.895	539.752	540.232	lower clay - bedrock	
GA - 6-2	6973.085	8149.895	539.752	540.232	red till - lower sand	
GA - 7-1	6774.648	7758.687	534.764	535.364	red till - bedrock	
GA - 8A-1	6503.915	7242.850	513.965	514.502	bedrock	
GA - 8B-1	6505.985	7242.513	513.987	514.667	alluvium	
GA - 9A-1	7035.667	7741.694	518.861	519.541	upper sand - bedrock	
GA - 9B-1	7036.534	7743.014	519.160	519.440	upper sand	
GA - 9B-2	7036.534	7743.014	519.160	519.440	upper sand	
GA - 10A-1	7223.849	7996.876	516.171	516.761	trench clay - bedrock	
GA - 10B-1	7222.533	7997.854	516.348	516.978	upper sand	
GA - 11-1	7525.332	8700.969	515.524	516.064	bedrock	
GA - 11-2	7525.332	8700.969	515.524	516.064	upper sand	dry
GA - 11-3	7525.332	8700.969	515.524	516.064	upper clay	
GA - 12-1	7517.021	9051.131	515.222	515.801	red till - lower sand	
GA - 12-2	7517.021	9051.131	515.222	515.801	upper sand	
GA - 13-1	7287.508	9153.832	525.251	525.971	lower sand - bedrock	standing water
GA - 14A-1	7299.490	8348.537	514.001	514.461	lower sand - bedrock	
GA - 14B-1	7300.582	8347.555	514.033	514.533	upper sand	
GA - 15-1	7255.881	8721.772	518.559	518.908	trench clay	
GA - 15-2	7255.881	8721.772	518.559	518.908	trench clay	dry
GA - 15-3	7255.881	8721.772	518.559	518.908	upper clay	
GA - 16-1	7099.000	8535.434	519.226	519.962	upper sand - bedrock	standing water
GA - 17-1	6572.390	7677.688	532.371	532.841	bedrock	
GA - 18-1	7780.544	9273.828	517.766	518.121	lower sand	
GA - 18-2	7780.544	9273.828	517.766	518.121	red till	
GA - 19-1	7266.212	10105.579	517.279	517.869	bedrock	
GA - 19-2	7266.212	10105.579	517.279	517.869	upper clay - red till	
GA - 19-3	7266.212	10105.579	517.279	517.869	alluvium - upper clay	
GA - 20-1	7043.017	8674.507	521.479	522.153	upper sand - bedrock	dry
GA - 21-1	7235.020	8599.724	514.108	514.528	upper sand	
GA - 22A-1	7178.207	8263.366	518.161	519.373	red till - trench clay - bedrock	
GA - 22B-1	7179.547	8266.490	518.539	518.999	upper sand	dry
GA - 23-1	6824.277	8538.473	535.625	536.170	red till - bedrock	dry
GA - 24-1	7414.169	9022.798	514.981	515.667	upper clay - red till	
GA - 25-1	7414.782	8760.598	514.251	514.591	upper clay - red till	
GA - 26-1	7342.835	8466.476	514.625	515.079	red till	
GA - 26-2	7342.835	8466.476	514.625	515.079	alluvium	
GA - 27-1	7128.804	8123.087	527.329	527.942	lower clay - lower sand, trench sand	
GA - 28A-1	7654.217	9701.462	540.528	540.839	bedrock	
GA - 28B-1	7652.353	9702.656	540.647	541.225	red till	

NOTE: * - Elevation to mine datum

GTD101.WK1

TABLE D - 2
GROUNDWATER ELEVATIONS
GOLDER ASSOCIATES PIEZOMETERS - 1991

PIEZOMETER	GROUND SURFACE ELEV. (m) *	GROUNDWATER ELEVATION (m) *						
		22-Jul	23-Jul	24-Jul	25-Jul	26-Jul	29-Jul	30-Jul
GA - 1A-1	518.312	516.46	516.45	516.44	516.44	506.84	509.48	509.56
GA - 1A-2	518.312	509.76	509.76	509.76	509.75	509.20	512.31	512.96
GA - 1B-1	518.349	dry@ 510.71	dry@ 510.71	dry@ 510.71	dry@ 510.71	dry@ 510.71	dry@ 510.71	dry@ 510.71
GA - 2-1	519.537		513.89		513.67	513.63	513.64	513.64
GA - 2-2	519.537		518.04		517.52	517.60	517.90	517.84
GA - 3-1	523.739	512.62	512.83	512.82	512.79	512.78	512.75	512.74
GA - 3-2	523.739	521.87	521.86	521.85	521.83	521.82	521.85	521.84
GA - 4-1	516.960	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48
GA - 5-1	534.860	510.44	509.54	511.43	506.29	502.92	497.18	494.25
GA - 6-1	539.752							
GA - 6-2	539.752							
GA - 7-1	534.764							
GA - 8A-1	513.965							
GA - 8B-1	513.987							
GA - 9A-1	518.861							
GA - 9B-1	519.160							
GA - 9B-2	519.160							
GA - 10A-1	516.171							
GA - 10B-1	516.348							
GA - 11-1	515.524	502.88	502.77	502.65	502.56	502.44	502.28	502.21
GA - 11-2	515.524	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02
GA - 11-3	515.524	512.66	512.73	512.65	512.56	512.49	512.48	512.51
GA - 12-1	515.222	501.66	501.64	501.70	501.60	501.54	501.60	501.58
GA - 12-2	515.222	512.49	512.47	512.46	512.43	512.42	512.37	512.35
GA - 13-1	525.251							
GA - 14A-1	514.001							
GA - 14B-1	514.033							
GA - 15-1	518.559		481.41	481.46	481.40	481.30	481.29	481.27
GA - 15-2	518.559		dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90
GA - 15-3	518.559		510.50	510.49	510.49	510.45	510.41	510.43
GA - 16-1	519.226		500.73	500.72	500.71	500.70	499.34	499.42
GA - 17-1	532.371							
GA - 18-1	517.766	505.34	505.32	505.38	505.29	505.24	505.27	505.26
GA - 18-2	517.766	517.26	517.20	517.15	517.10	517.05	517.33	517.25
GA - 19-1	517.279		514.77	514.77	514.45	514.43	514.45	514.43
GA - 19-2	517.279		515.09	515.09	514.75	514.72	514.78	514.74
GA - 19-3	517.279		516.77	516.74	516.01	516.17	516.38	516.32
GA - 20-1	521.479		dry@ 504.16	dry@ 504.16	dry@ 504.16	dry@ 504.16	dry@ 503.16	dry@ 503.16
GA - 21-1	514.108		509.77	509.78	509.76	509.73	509.62	509.61
GA - 22A-1	518.161							
GA - 22B-1	518.539		dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64
GA - 23-1	535.625					472.09	dry@ 468.22	dry@ 470.45
GA - 24-1	514.981					511.11	510.71	510.47
GA - 25-1	514.251					512.68	512.97	512.94
GA - 26-1	514.625					513.85	513.89	513.87
GA - 26-2	514.625					514.01	513.96	513.92
GA - 27-1	527.329							
GA - 28A-1	540.528							
GA - 28B-1	540.647							

NOTE: * - Elevation to mine datum

TABLE D - 2
GROUNDWATER ELEVATIONS
GOLDER ASSOCIATES PIEZOMETERS - 1991

PIEZOMETER	GROUND SURFACE ELEV. (m) *	GROUNDWATER ELEVATION (m) *						
		31-Jul	01-Aug	02-Aug	06-Aug	07-Aug	08-Aug	09-Aug
GA - 1A-1	518.312	509.61	509.64	509.66	510.03	509.82	509.73	509.68
GA - 1A-2	518.312	513.47	513.89	514.12	515.60	515.88	516.17	516.33
GA - 1B-1	518.349	510.73	510.82	510.94	516.27	516.29	516.30	516.33
GA - 2-1	519.537	513.67	513.69	513.70	513.63	513.61	513.64	513.60
GA - 2-2	519.537	517.78	517.79	517.84	518.10	518.03	517.94	517.87
GA - 3-1	523.739	512.74	512.74	512.76	512.70	512.71	512.60	512.59
GA - 3-2	523.739	521.82	521.83	521.82	521.86	521.89	521.79	521.75
GA - 4-1	516.960	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48
GA - 5-1	534.860	494.71	494.05	494.09	504.60	502.40	500.53	
GA - 6-1	539.752					499.63	499.61	499.93
GA - 6-2	539.752					510.73	510.73	510.68
GA - 7-1	534.764							
GA - 8A-1	513.965							
GA - 8B-1	513.987							
GA - 9A-1	518.861	504.95	504.78	504.57	503.76	503.26	503.39	503.62
GA - 9B-1	519.160							
GA - 9B-2	519.160							
GA - 10A-1	516.171	503.89	503.73	503.53	502.85	502.72	502.74	503.03
GA - 10B-1	516.348	510.07	510.26	510.27	510.15	510.59	510.80	510.86
GA - 11-1	515.524	502.17	502.13	502.10	502.02	502.01	502.01	501.99
GA - 11-2	515.524	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02
GA - 11-3	515.524	512.53	512.55	512.56	512.46	512.46	512.48	512.44
GA - 12-1	515.222	501.60	501.66	501.70	501.77	501.75	501.79	501.74
GA - 12-2	515.222	512.33	512.39	512.37	512.74	512.72	512.68	512.65
GA - 13-1	525.251				465.12	465.16	464.81	464.66
GA - 14A-1	514.001	510.43	510.45	510.48	508.59	508.63	508.62	508.62
GA - 14B-1	514.033	497.94	497.92	497.90	498.15	498.10	498.05	498.06
GA - 15-1	518.559	481.32	481.31	481.35	481.22	481.26	481.23	481.18
GA - 15-2	518.559	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90
GA - 15-3	518.559	510.44	510.41	510.43	510.43	510.45	510.43	510.45
GA - 16-1	519.226	499.59	499.79	499.96	499.96	500.30	500.53	500.66
GA - 17-1	532.371					492.92	494.00	494.46
GA - 18-1	517.766	505.29	505.31	505.34	505.29	505.27	505.29	505.24
GA - 18-2	517.766	517.20	517.20	517.23				517.44
GA - 19-1	517.279	514.41	514.44	514.45	514.41	514.40	514.41	514.38
GA - 19-2	517.279	514.74	514.75	514.76	514.76	514.77	514.77	514.74
GA - 19-3	517.279	516.26	516.29	516.35	516.46	516.74	516.39	516.34
GA - 20-1	521.479	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16
GA - 21-1	514.108	509.62	509.61	509.61	509.57	509.59	509.59	509.60
GA - 22A-1	518.161							
GA - 22B-1	518.539	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 510.10	dry@ 509.64	dry@ 509.64	dry@ 509.64
GA - 23-1	535.625	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	475.51	472.72
GA - 24-1	514.981	510.43	510.42	510.41	508.90	509.97	510.26	510.32
GA - 25-1	514.251	512.95	512.73	512.91	513.10	513.09	513.06	513.02
GA - 26-1	514.625	513.87	513.88	513.87		513.91	513.90	513.89
GA - 26-2	514.625	513.90	513.88	513.87		513.89	513.90	513.89
GA - 27-1	527.329							
GA - 28A-1	540.528							
GA - 28B-1	540.647							

NOTE: * - Elevation to mine datum

GTD2.WK1

TABLE D - 2
GROUNDWATER ELEVATIONS
GOLDER ASSOCIATES PIEZOMETERS - 1991

PIEZOMETER	GROUND SURFACE ELEV. (m) *	GROUNDWATER ELEVATION (m) *						
		12-Aug	14-Aug	16-Aug	19-Aug	21-Aug	23-Aug	26-Aug
GA - 1A-1	518.312	509.65	509.64	509.63	509.59	509.61	509.62	509.63
GA - 1A-2	518.312	516.45	516.54	516.58	516.55	516.86	517.36	517.15
GA - 1B-1	518.349	516.39	516.38	516.47	516.50	516.58	516.70	516.88
GA - 2-1	519.537	513.65	513.62	513.63	513.59	513.61	513.68	513.70
GA - 2-2	519.537	518.21	518.07	518.00	518.32	518.34	518.34	517.79
GA - 3-1	523.739	512.52	512.49	512.49	512.45	512.48	512.50	512.52
GA - 3-2	523.739	521.80	521.79	521.73	521.67	521.91	521.96	521.88
GA - 4-1	516.960	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48
GA - 5-1	534.860	499.18	499.18	499.28	498.92	498.60	498.14	497.69
GA - 6-1	539.752	500.15	500.25	500.52	500.33	500.34	500.68	501.63
GA - 6-2	539.752	510.76	510.74	510.78	510.68	510.64	510.71	510.69
GA - 7-1	534.764			514.99	513.87	501.68	503.78	505.96
GA - 8A-1	513.965					512.27	512.44	
GA - 8B-1	513.987					512.77	512.81	
GA - 9A-1	518.861	503.72	504.38	504.87	504.66	504.89	505.62	506.56
GA - 9B-1	519.160		509.14	dry@ 508.49	dry@ 508.49	dry@ 508.49	dry@ 508.49	dry@ 508.49
GA - 9B-2	519.160		509.92	509.90	509.84	509.51	509.46	509.40
GA - 10A-1	516.171	503.24	503.64	504.04	503.96	504.13	504.74	505.59
GA - 10B-1	516.348	511.13	511.24	511.20	510.98	511.27	511.38	511.23
GA - 11-1	515.524	501.96	501.95	501.92	501.93	501.90	506.92	502.00
GA - 11-2	515.524	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02
GA - 11-3	515.524	512.54	512.68	512.74	512.62	512.73	513.03	513.02
GA - 12-1	515.222	501.82	501.82	501.80	501.72	501.68	501.78	501.66
GA - 12-2	515.222	512.95	512.89	512.83	512.72	513.44	513.74	513.60
GA - 13-1	525.251	464.43	464.36	464.30	464.23	464.20	464.19	464.18
GA - 14A-1	514.001	508.63	508.60	508.57	508.57	508.61	508.67	508.63
GA - 14B-1	514.033	498.07	498.16	498.32	498.31	497.78	498.38	498.86
GA - 15-1	518.559	481.23	481.21	481.20	481.14	481.13	481.16	481.19
GA - 15-2	518.559	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90
GA - 15-3	518.559	510.68	510.65	510.64	510.16	510.71	510.68	510.72
GA - 16-1	519.226	500.70	500.71	500.70	500.71	500.68	500.66	500.71
GA - 17-1	532.371	494.02	494.26	494.45	493.85	493.61	493.75	493.59
GA - 18-1	517.766	505.27	505.25	505.25	505.18	505.13	505.20	505.16
GA - 18-2	517.766							517.30
GA - 19-1	517.279	514.42	514.46		514.38	514.67	514.87	514.69
GA - 19-2	517.279	514.86	514.83		515.32	515.63	515.69	515.60
GA - 19-3	517.279	516.58	516.56		516.38	516.68	516.65	516.61
GA - 20-1	521.479	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16
GA - 21-1	514.108	509.80	509.75	509.67	510.02	510.51	510.78	510.03
GA - 22A-1	518.161					499.07	499.53	501.32
GA - 22B-1	518.539	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64
GA - 23-1	535.625	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49
GA - 24-1	514.981	511.80	510.65	512.80	512.74	513.12	513.24	513.11
GA - 25-1	514.251	513.46	513.31	513.17	513.08	513.87	513.94	513.92
GA - 26-1	514.625	514.00	513.98	513.90	513.91	514.13	514.18	514.06
GA - 26-2	514.625	514.00	513.98	513.90	513.89	514.13	514.18	514.05
GA - 27-1	527.329		504.09	504.36	504.35	503.87	504.60	505.29
GA - 28A-1	540.528						524.16	522.20
GA - 28B-1	540.647						540.30	539.85

NOTE: * - Elevation to mine datum

TABLE D - 2
GROUNDWATER ELEVATIONS
GOLDER ASSOCIATES PIEZOMETERS - 1991

PIEZOMETER	GROUND SURFACE ELEV. (m) *	GROUNDWATER ELEVATION (m) *						
		28-Aug	30-Aug	04-Sep	06-Sep	09-Sep	11-Sep	18-Sep
GA - 1A-1	518.312	509.66	509.66	509.67	509.66	509.66	509.68	509.66
GA - 1A-2	518.312	517.08	517.08	516.97	516.91	516.97	517.00	517.00
GA - 1B-1	518.349	516.96	517.00	517.03	517.01	517.01	517.03	517.05
GA - 2-1	519.537	513.26	513.25	513.68	513.61	513.63	513.71	513.64
GA - 2-2	519.537	517.46	517.77	518.07	518.01	518.27	518.29	518.19
GA - 3-1	523.739	512.49	512.08	512.51	512.46	512.46	512.52	512.44
GA - 3-2	523.739	521.85	521.38	521.76	521.73	521.82	521.78	521.76
GA - 4-1	516.960	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48
GA - 5-1	534.860	498.72	499.83	499.16	499.43	499.14	498.32	497.49
GA - 6-1	539.752	502.21	502.21	502.23	501.85	501.57	501.31	501.24
GA - 6-2	539.752	510.76	510.80	510.82	510.67	510.71	510.85	510.69
GA - 7-1	534.764	507.22	508.33	510.50	510.96	511.46	511.61	511.43
GA - 8A-1	513.965	512.32	512.27	512.46	512.39	512.35	512.30	512.13
GA - 8B-1	513.987	512.80	512.81	512.78	512.75	512.76	512.74	512.52
GA - 9A-1	518.861	506.96	507.04	507.29	507.17	506.91	506.83	506.94
GA - 9B-1	519.160	dry@ 508.49	dry@ 508.49	dry@ 508.49	dry@ 508.49	dry@ 508.49	dry@ 508.49	dry@ 508.49
GA - 9B-2	519.160	509.40	509.36	509.30	509.28	509.24	509.21	509.04
GA - 10A-1	516.171	506.00	506.12	506.18	506.13	505.90	505.70	505.96
GA - 10B-1	516.348	511.06	511.25	511.12	510.95	511.01	510.93	511.06
GA - 11-1	515.524	501.98	501.96	501.92	501.89	501.89	501.90	502.04
GA - 11-2	515.524	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02	dry@ 507.02
GA - 11-3	515.524	513.09	513.12	513.03	512.89	512.93	513.06	512.96
GA - 12-1	515.222	501.72	501.80	501.69	501.55	501.58	501.78	501.57
GA - 12-2	515.222	513.44	513.36	513.20	513.13	513.25	513.23	513.34
GA - 13-1	525.251	464.16	464.16	464.15	464.12	464.12	464.09	464.08
GA - 14A-1	514.001	508.59	508.56	508.53	508.50	508.49	508.46	508.46
GA - 14B-1	514.033	499.38	498.97	498.65	498.54	498.56	498.58	498.48
GA - 15-1	518.559	481.17	481.20	481.24	481.08	481.12	481.23	481.06
GA - 15-2	518.559	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90
GA - 15-3	518.559	510.66	510.53	510.69	510.63	510.64	510.61	510.58
GA - 16-1	519.226	500.69	500.69	500.54	500.68	500.66	500.68	500.65
GA - 17-1	532.371	493.56	493.52	493.04	493.35	493.42	493.62	493.16
GA - 18-1	517.766	505.19	505.22	505.21	505.10	505.12	505.27	505.07
GA - 18-2	517.766	517.50	517.53	517.54	517.37	517.52	517.52	517.50
GA - 19-1	517.279	514.73	514.68	514.63	514.57	514.60	514.64	514.58
GA - 19-2	517.279	515.61	515.60	515.57	515.53	515.57	515.60	515.58
GA - 19-3	517.279	516.64	516.62	516.54	516.54	516.62	516.65	516.58
GA - 20-1	521.479	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16
GA - 21-1	514.108	509.82	509.83	509.68	509.61	509.65	509.64	509.57
GA - 22A-1	518.161	502.53	502.50	502.27	501.54	500.97	500.26	500.12
GA - 22B-1	518.539	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64
GA - 23-1	535.625	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49
GA - 24-1	514.981	513.07	513.05	512.94	512.88	512.99	512.94	512.96
GA - 25-1	514.251	513.71	513.88	513.79	513.75	513.84	513.83	513.84
GA - 26-1	514.625	514.05	514.08	514.01	513.96	514.06	514.03	514.05
GA - 26-2	514.625	514.05	514.08	514.01	513.96	514.06	514.03	514.05
GA - 27-1	527.329	505.73	505.83	506.04	505.84	505.60	505.41	505.66
GA - 28A-1	540.528	521.50	520.89	519.37	518.82	518.08	517.64	516.30
GA - 28B-1	540.647	539.93	540.00	539.80		540.06	539.97	539.93

NOTE: * - Elevation to mine datum

TABLE D - 2
GROUNDWATER ELEVATIONS
GOLDER ASSOCIATES PIEZOMETERS - 1991

PIEZOMETER	GROUND SURFACE ELEV. (m) *	GROUNDWATER ELEVATION (m) *					
		25-Sep	02-Oct	09-Oct	16-Oct	23-Oct	30-Oct
GA - 1A-1	518.312	509.74	509.78	509.89	509.91	509.95	509.97
GA - 1A-2	518.312	517.52	517.89	517.87	517.51	517.45	517.40
GA - 1B-1	518.349	517.56	517.78	517.92	517.56	517.47	517.43
GA - 2-1	519.537	513.82	513.97	514.03	514.04	514.00	513.98
GA - 2-2	519.537	518.37	518.50	518.19	518.33	518.36	518.33
GA - 3-1	523.739	512.56	512.63	512.70	512.83	512.99	512.79
GA - 3-2	523.739	521.96	521.60	522.09	521.96	521.91	521.86
GA - 4-1	516.960	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48	dry@ 497.48
GA - 5-1	534.860	495.78	495.90	500.51	501.26	501.53	500.32
GA - 6-1	539.752	501.86	502.48	504.21	502.90	502.34	501.65
GA - 6-2	539.752	510.77	510.73	510.65	510.67	510.59	510.64
GA - 7-1	534.764	511.56	511.63	511.61	511.53	511.34	511.26
GA - 8A-1	513.965	511.66	513.32	513.08	512.70	511.70	511.65
GA - 8B-1	513.987	512.80	513.34	513.17	512.91	512.33	512.36
GA - 9A-1	518.861	507.90	508.60	509.46	508.25	507.12	506.10
GA - 9B-1	519.160	dry@ 508.49	508.83	509.71	508.57	dry@ 508.49	dry@ 508.49
GA - 9B-2	519.160	508.94	508.89	509.38	509.38	509.16	508.87
GA - 10A-1	516.171	507.11	507.83	509.05	507.61	506.54	505.54
GA - 10B-1	516.348	511.53	511.74	512.15	511.29	510.86	510.54
GA - 11-1	515.524	503.57	503.83	511.52	504.22	503.58	503.56
GA - 11-2	515.524	dry@ 507.02	dry@ 507.02	509.57	508.08	508.00	dry@ 507.02
GA - 11-3	515.524	513.31	513.43	513.65	513.37	513.28	513.23
GA - 12-1	515.222	501.64	501.69	501.66	501.71	501.68	501.59
GA - 12-2	515.222	514.68	514.86	515.03	514.57	514.47	514.46
GA - 13-1	525.251	464.07	464.06	464.05	464.04	464.04	434.04
GA - 14A-1	514.001	508.87			508.72	508.43	508.39
GA - 14B-1	514.033	498.69			499.13	498.88	498.70
GA - 15-1	518.559	481.19	480.11	481.01	481.09	481.02	481.01
GA - 15-2	518.559	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90	dry@ 482.90
GA - 15-3	518.559	510.77	510.81	510.90	510.71	510.59	510.61
GA - 16-1	519.226	500.65	500.67	500.65	500.64	500.64	500.63
GA - 17-1	532.371	493.39	493.50	493.39	493.36	493.29	493.04
GA - 18-1	517.766	505.25	505.36	505.45	505.49	505.45	505.47
GA - 18-2	517.766						
GA - 19-1	517.279	515.52	516.00	516.07	515.52	515.50	515.33
GA - 19-2	517.279	516.12	516.29	516.41	516.13	516.07	516.03
GA - 19-3	517.279	516.66	516.77	516.71	516.65	516.68	516.66
GA - 20-1	521.479	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16	dry@ 503.16
GA - 21-1	514.108				510.45	509.73	509.42
GA - 22A-1	518.161	500.80	501.77	505.19	503.55	502.91	501.97
GA - 22B-1	518.539	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64	dry@ 509.64
GA - 23-1	535.625	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49	dry@ 470.49
GA - 24-1	514.981	513.38	513.46		513.27	513.24	513.14
GA - 25-1	514.251	514.05	514.28		514.07	514.06	514.00
GA - 26-1	514.625	514.31	514.48		514.25	514.17	514.10
GA - 26-2	514.625	514.31	514.48		514.25	514.17	514.10
GA - 27-1	527.329	506.74	507.48	508.80	507.41	506.37	505.40
GA - 28A-1	540.528	515.57	514.97	514.49	514.05	513.68	513.32
GA - 28B-1	540.647	540.27	540.48	540.27	540.18	540.32	540.22

NOTE: * - Elevation to mine datum

GTD2.WK1

TABLE D - 3
GROUNDWATER ELEVATIONS
PRE-EXISTING MONITORING WELLS - 1991

WELL	REFERENCE ELEVATION (metres) *	**	GROUNDWATER ELEVATION (m) *										
		10-Apr-89	27-Dec-90	02-Jan-91	09-Jan-91	16-Jan-91	23-Jan-91	30-Jan-91	06-Feb-91	13-Feb-91	20-Feb-91	27-Feb-91	06-Mar-91
OW-1A	518.2	514.84	475.71 - dry level	475.71 - dry level	475.71 -dry level	475.71 - dry level	475.71 - dry level	475.71 - dry level	475.71 - dry level	475.71 - dry level	475.71 - dry level	475.71 - dry level	475.71 - dry level
OW-2	522.4	517.33	501.91	501.94	501.93	501.92	501.81	501.81	501.79	no reading	501.76		501.73
OW-3	519.3	515.64	490.65	490.86	490.77	490.78	490.22	490.78	490.71	no reading	490.94	490.91	490.86
OW-6	545	522.68	521.69	521.69	521.68	521.71	521.70	521.68	521.69	521.78	521.83	521.66	521.82
DW-1	518.5	515.22	477.53	477.71	477.55	477.57	477.69	477.74	477.62	477.66	477.90	478.00	478.20
DW-2	525.3	515.24	500.69	500.91	500.79	500.79	500.64	500.49	500.47	500.60	500.72	500.54	500.43
DW-3	530.5	510.94	457.91	446.21	445.68	453.81	442.90	440.86	445.42	442.82	443.16	445.21	446.32
ETW-1	535.2	513.90	458.86	449.21	446.72 - dry level	454.63	446.72 - dry level	446.72 - dry level	446.72 - dry level	446.72 - dry level	446.72 - dry level	446.72 - dry level	446.72 - dry level
ETW-2	542.8	511.07	459.66	456.61	456.08	456.64	456.42	455.92	455.83	455.30	455.50	455.66	454.88
ETW-3	546.7	512.93	479.31	479.39	479.29	479.31	479.14	479.34	479.31	479.46	479.28	479.10	478.74
ETW-4	521.3	515.53	482.85	482.87	482.88	482.89	482.87	482.91	482.89	482.88	482.88	482.88	482.89
H-4	550.1	514.30	460.05	459.36	459.11	459.17	459.08	458.94	458.65	458.63	456.27	458.29 -dry level	458.29 -dry level
H-5	515.3	515.07	506.92	506.49	506.11	505.83		506.04	505.99	506.04	506.22	506.29	not taken
H-7	519.4		475.88 - dry level	475.88 - dry level	475.88 - dry level	475.88 - dry level	475.88 - dry level	475.88 - dry level	475.88 - dry level	475.88 - dry level	475.88 - dry level	475.88 - dry level	475.88 - dry level
P-4	533.2												
P-6	515.8												
DDH 733	545.9	511.17	486.17 - dry level	486.17 - dry level	486.17 - dry level	486.17 - dry level	486.17 - dry level	486.17 - dry level	486.17 - dry level	486.17 - dry level	486.17 - dry level	486.17 - dry level	486.17 - dry level
DDH 738	549.1	514.24	471.00	471.00 - dry level	471.00 - dry level	471.00 - dry level	471.00 - dry level	471.00 - dry level	471.00 - dry level	471.00 - dry level	471.00 - dry level	471.00 - dry level	471.00 - dry level
DDH 817	531.8		448.38	445.76	444.86	444.11	492.15	480.73	481.80	no reading	no reading	no reading	530.30

NOTE: * - Elevation to mine datum

** - Groundwater elevation prior to dewatering

GTD301.WK1

TABLE D - 3
GROUNDWATER ELEVATIONS
PRE-EXISTING MONITORING WELLS - 1991

WELL	REFERENCE ELEVATION (metres) *	GROUNDWATER ELEVATION (m) *											
		13-Mar-91	20-Mar-91	27-Mar-91	03-Apr-91	10-Apr-91	17-Apr-91	24-Apr-91	01-May-91	08-May-91	15-May-91	22-May-91	29-May-91
OW-1A	518.2	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level	475.71 -dry level
OW-2	522.4	501.71	501.67	501.64	501.58	501.57	501.51	501.30	500.98	501.01	500.96	501.40	501.37
OW-3	519.3	490.85	491.02	490.82	490.59	490.88	490.84	490.87	490.85	490.86	490.80	490.87	490.86
OW-6	545	521.84	521.86	521.85	521.78	521.80	521.79	521.82	521.32	521.82	521.81	521.80	521.81
DW-1	518.5	478.44	478.56	478.35	478.33	478.48	478.44	478.53	478.42	478.41	478.45	478.47	478.46
DW-2	525.3	500.69	500.91	500.68	500.61	500.72	500.63	500.65	500.62	500.59	500.58	500.60	500.59
DW-3	530.5	454.00	448.25	448.34	448.84	441.86	440.35	443.33	454.86	458.36	459.78	460.60	462.09
ETW-1	535.2	455.37	450.10	449.10	449.34	446.72 -dry level	446.72 -dry level	446.72 -dry level	456.17	459.47	461.40	461.40	463.59
ETW-2	542.8	456.76	455.80	455.69	456.01	455.57	455.20	455.79	456.83	459.89	460.39	459.73	461.00
ETW-3	546.7	478.51	478.56	477.92	477.54	477.48	477.33	477.31	477.04	476.83	476.72	476.56	476.40
ETW-4	521.3	482.93	482.93	482.92	482.93	482.93	482.93	482.92	482.94	482.93	482.97	482.98	482.98
H-4	550.1	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level	458.29 -dry level
H-5	515.3	506.72	506.72	506.29	506.40	506.37	506.53	Flooded	505.36	506.86	506.52	506.54	506.57
H-7	519.4	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level	475.88 -dry level
P-4	533.2												
P-6	515.8												
DDH 733	545.9	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level	486.17 -dry level
DDH 738	549.1	471.00 -dry level	471.00 -dry level	471.00 -dry level	471.00 -dry level	471.00 -dry level	471.00 -dry level	472.81	473.18	473.06	473.01	472.83	472.99
DDH 817	531.8	523.60	515.27	508.42	501.98	497.65	493.38	489.57	485.85	482.39	479.77	477.59	475.18

NOTE: * - Elevation to mine datum

GTD301.WK

TABLE D - 3
GROUNDWATER ELEVATIONS
PRE-EXISTING MONITORING WELLS - 1991

WELL	REFERENCE ELEVATION (metres) *	GROUNDWATER ELEVATION (m) *											
		06-Jun-91	12-Jun-91	19-Jun-91	26-Jun-91	03-Jul-91	10-Jul-91	17-Jul-91	24-Jul-91	31-Jul-91	07-Aug-91	14-Aug-91	21-Aug-91
OW-1A	518.2	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71
OW-2	522.4	501.32	501.29	501.25	487.31	486.99	486.96	486.94	486.92	486.91	486.88	486.88	486.86
OW-3	519.3	490.80	490.91	490.78	490.86	490.76	490.88	490.81	490.87	490.81	490.79	490.83	490.73
OW-6	545	521.78	521.81	521.77	521.77	521.76	521.77	521.61	521.75	521.71	521.70	521.72	521.71
DW-1	518.5	478.37	478.44	478.19	478.15	478.05	478.09	478.04	477.94	477.70	477.62	477.45	477.17
DW-2	525.3	500.57	500.68	500.53	500.55	500.45	500.58	500.52	500.53	500.48	500.45	500.48	500.23
DW-3	530.5	461.96	456.75	440.30	439.96	439.09	451.56	449.87	448.27	438.71	438.51	438.48	441.32
ETW-1	535.2	463.21	458.10	447.32	dry@ 447.37	dry@ 447.37	451.88	450.24	448.59	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37
ETW-2	542.8	459.46	455.92	452.31	451.25	451.34	451.49	451.62	450.73	447.29	444.66	445.11	447.09
ETW-3	546.7	476.20	476.24	476.07	476.06	476.18	475.14	474.89	475.10	476.00	473.08	474.43	473.90
ETW-4	521.3	482.96	482.93	482.88	482.81	482.75	482.68	482.61	482.53	482.45	482.42	482.39	482.31
H-4	550.1	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29
H-5	515.3	506.15	506.07	505.99	505.92	505.99	506.06	505.95	506.27	506.34	506.41	506.50	506.56
H-7	519.4	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88
P-4	533.2									527.09	527.08	527.08	527.15
P-6	515.8									510.82	510.93	511.08	511.19
DDH 733	545.9	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17
DDH 738	549.1	472.84	472.92	472.90	472.91	472.86	472.96	472.94	472.87	472.83	472.56	472.85	472.74
DDH 817	531.8	472.61	471.89	469.03	467.29	465.67	464.16	462.65	461.47	460.25	459.10	458.04	457.03

NOTE: * - Elevation to mine datum

GTD301.WK

TABLE D - 3
GROUNDWATER ELEVATIONS
PRE-EXISTING MONITORING WELLS - 1991

WELL	REFERENCE ELEVATION [metres] *	GROUNDWATER ELEVATION (m) *							
		28-Aug-91	04-Sep-91	11-Sep-91	18-Sep-91	25-Sep-91	02-Oct-91	09-Oct-91	16-Oct-91
OW-1A	518.2	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71	dry@ 475.71
OW-2	522.4	486.86	486.84	486.83	486.81	486.83	486.86	486.88	486.86
OW-3	519.3	490.84	490.88	490.94	490.79	490.88	490.83	490.74	490.77
OW-6	545	521.26	521.73	521.72	521.73	521.72	521.71	521.71	521.71
DW-1	518.5	477.39	477.50	477.60	477.47	477.65	477.73	478.07	478.21
DW-2	525.3	500.35	500.39	500.61	500.44	500.58	500.56	500.54	500.59
DW-3	530.5	442.17	441.71	438.72	439.97	449.03	439.72	444.37	437.92
ETW-1	535.2	dry@ 447.37	dry@ 447.37	dry@ 447.37	dry@ 447.37	448.20	dry@ 447.37	dry@ 447.37	dry@ 447.37
ETW-2	542.8	452.32	453.11	452.70	452.68	453.89	454.36	454.98	454.51
ETW-3	546.7	474.86	472.77	475.88	473.69	473.97	473.52	472.44	472.32
ETW-4	521.3	482.25	482.19	482.13	482.06	482.00	481.96	481.93	481.94
H-4	550.1	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29	dry@ 458.29
H-5	515.3	506.30	506.95	506.94	507.00	507.42	508.07		507.94
H-7	519.4	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88	dry@ 475.88
P-4	533.2	527.26	527.24	527.22	527.25	527.45	527.53	527.69	527.41
P-6	515.8	511.22	511.24	511.23	511.2	512.08	512.44	512.09	512.23
DDH 733	545.9	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17	dry@ 486.17
DDH 738	549.1	472.89	473.01	472.59	472.34	472.43	472.34	472.17	472.06
DDH 817	531.8	455.67	455.49	454.32	453.66	452.93	452.20	450.80	451.95

NOTE: * - Elevation to mine datum

GTD301.WK1

TABLE D - 4
GROUNDWATER ELEVATION
UNDERGROUND MONITORING LOCATIONS - 1991

POINT	LOCATION	GAUGE ELEV. m *	ELEVATION HEADS (m) *																
			11-Jun	19-Jun	27-Jun	03-Jul	10-Jul	18-Jul	26-Jul	31-Jul	09-Aug	15-Aug	22-Aug	05-Sep	12-Sep	18-Sep	26-Sep	04-Oct	09-Oct	17-Oct
PT-1	118 Sump	410.00	453.7	431.5	428.3	431.8	438.9	445.2	435.3	431.1	426.2	430.4	429.7	438.2	439.6	438.2	443.1	449.4	440.3	431.8
PT-2	825 Ramp	441.04	451.6	450.9	450.2	450.2	450.2	450.9	450.2	448.1	443.9	448.1	449.5	452.3	451.6	451.6	452.3	452.3	453.0	452.7
PT-3	808 Sump	421.50	435.6	425.7	427.1	426.4	427.8	427.8	427.8	426.4	425.7	427.1	427.1	427.8	427.8	427.8	427.8	429.2	429.2	428.9
PT-4	848 Ramp	441.86	446.8	**	**	**	444.0	**	**	**	**	**	**	**	**	**	**	**	**	**
PT-5	851 Decline	428.68	441.4	440.3	440.3	440.3	440.3	440.3	440.3	440.3	440.3	440.3	440.3	440.3	440.6	440.3	440.3	440.3	440.3	440.3
PT-6	803 Sump	427.35	435.1	433.0	437.9	439.3	442.1	441.4	441.8	443.5	443.5	445.0	445.7	440.0	443.5	442.1	442.8	443.5	442.8	444.2
PT-7	101-Drift	412.00	416.9	415.5	415.5	415.5	415.5	415.5	415.5	415.5	415.5	415.5	415.5	**	**	**	**	414.5	414.5	414.5
PT-8	119 Sump	428.00	**	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	449.1	448.4
PT-9	201 Drift	471.80	483.8	485.9	485.9	485.9	485.9	484.5	484.5	484.5	484.5	484.5	484.5	484.5	485.2	485.2	485.2	485.2	485.2	485.2
PT-10	118 Holes	407.50	444.8	427.9	425.8	425.1	430.0	418.8	429.3	425.1	413.8	413.8	413.8	**	**	**	**	**	**	**
PT-12	804 Hole	417.50	**	**	**	**	**	441.4	443.6	445.7	445.0	446.4	445.0	435.1	438.6	436.5	437.2	435.8	434.4	435.8

NOTE: * - Elevation to mine datum

** - No data available or zero pressure

GTD401.WK1

Groundwater Elevations

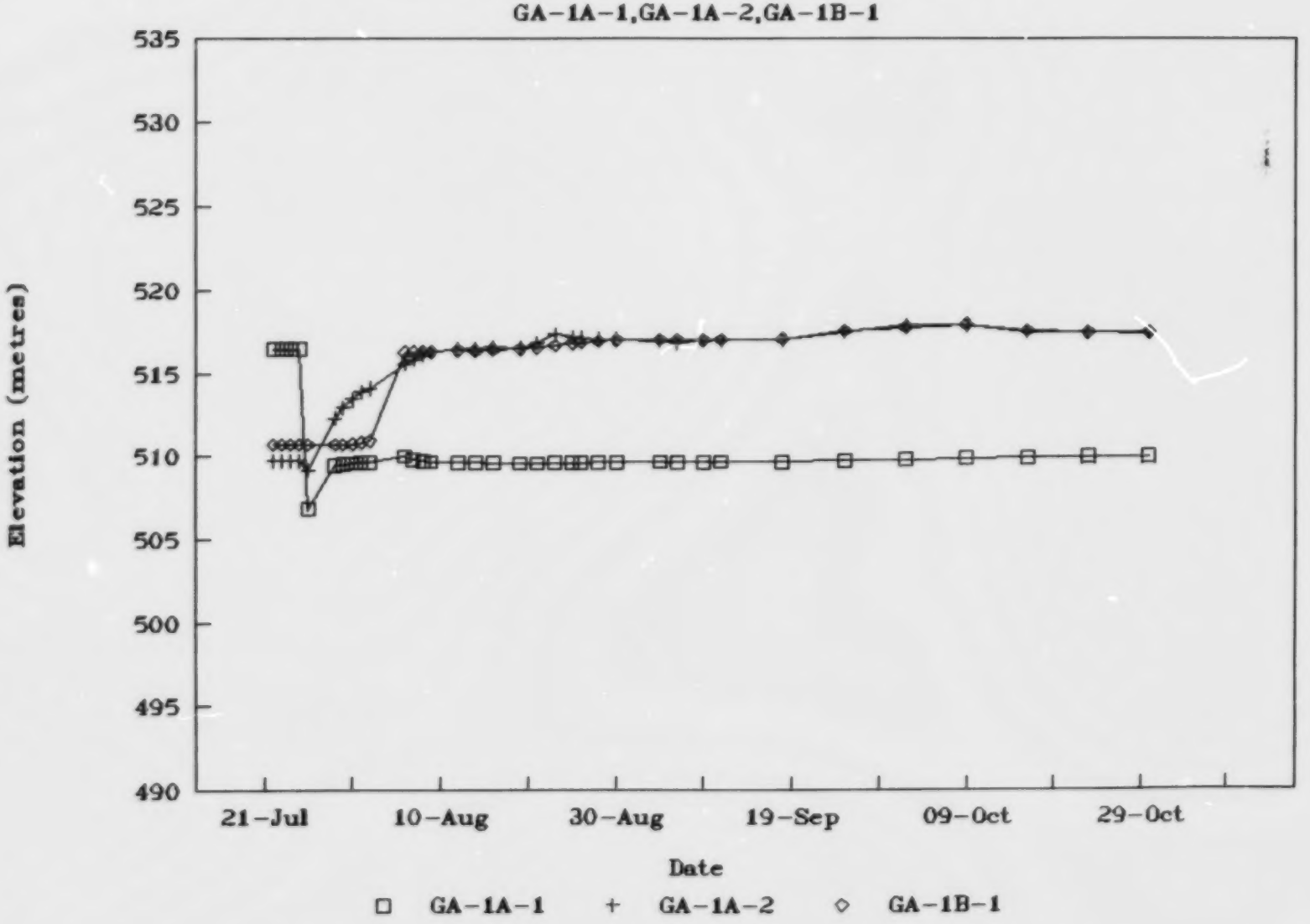


FIGURE D-1

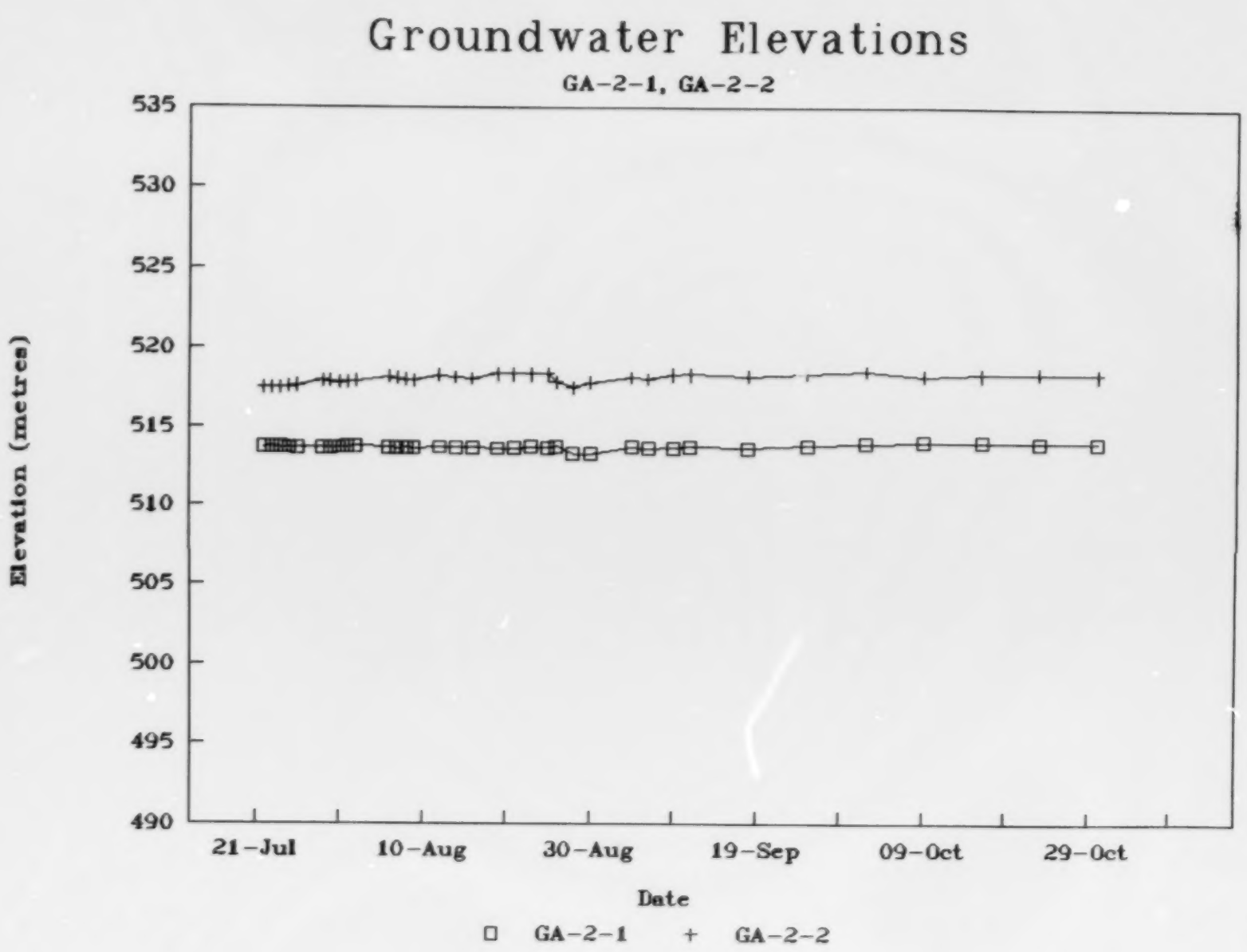

Groundwater Elevations
GA-2-1, GA-2-2
535
530
525
520
515
510
505
500
495
490
Elevation (metres)
21-Jul
10-Aug
30-Aug
19-Sep
09-Oct
29-Oct
Date
GA-2-1
GA-2-2

FIGURE D-2

Groundwater Elevations

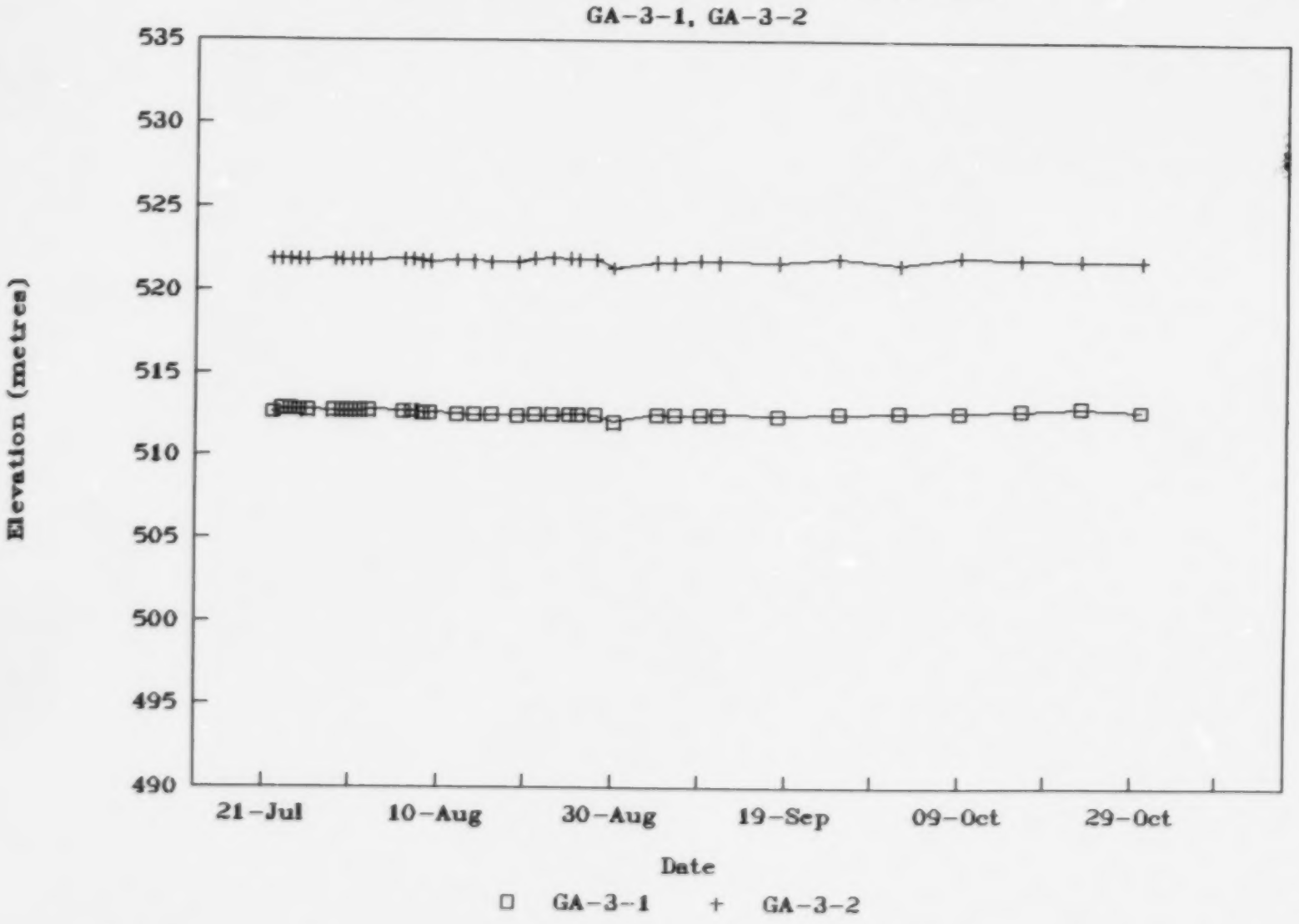


FIGURE D-3

Groundwater Elevations

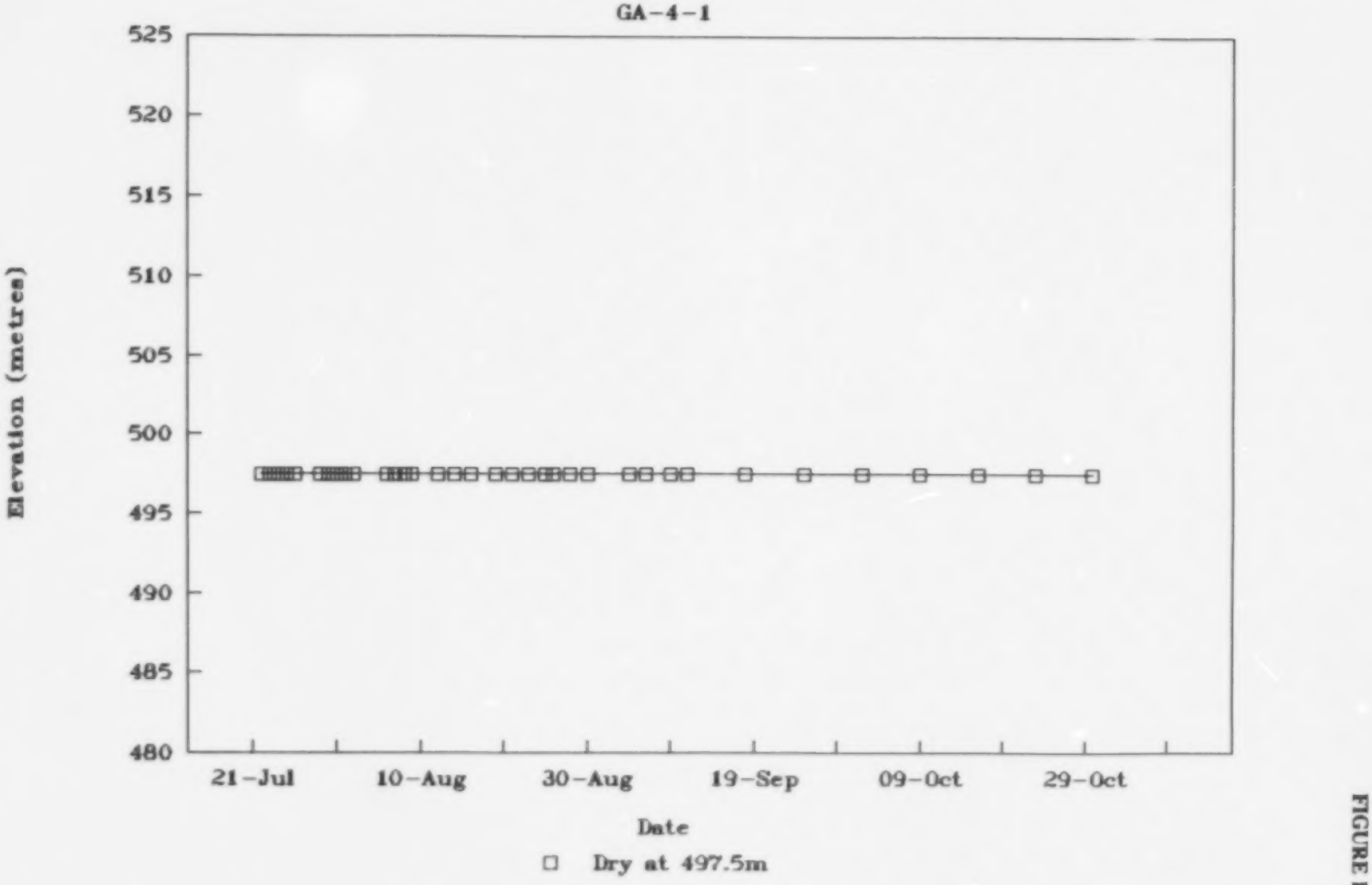


FIGURE D-4

Groundwater Elevations

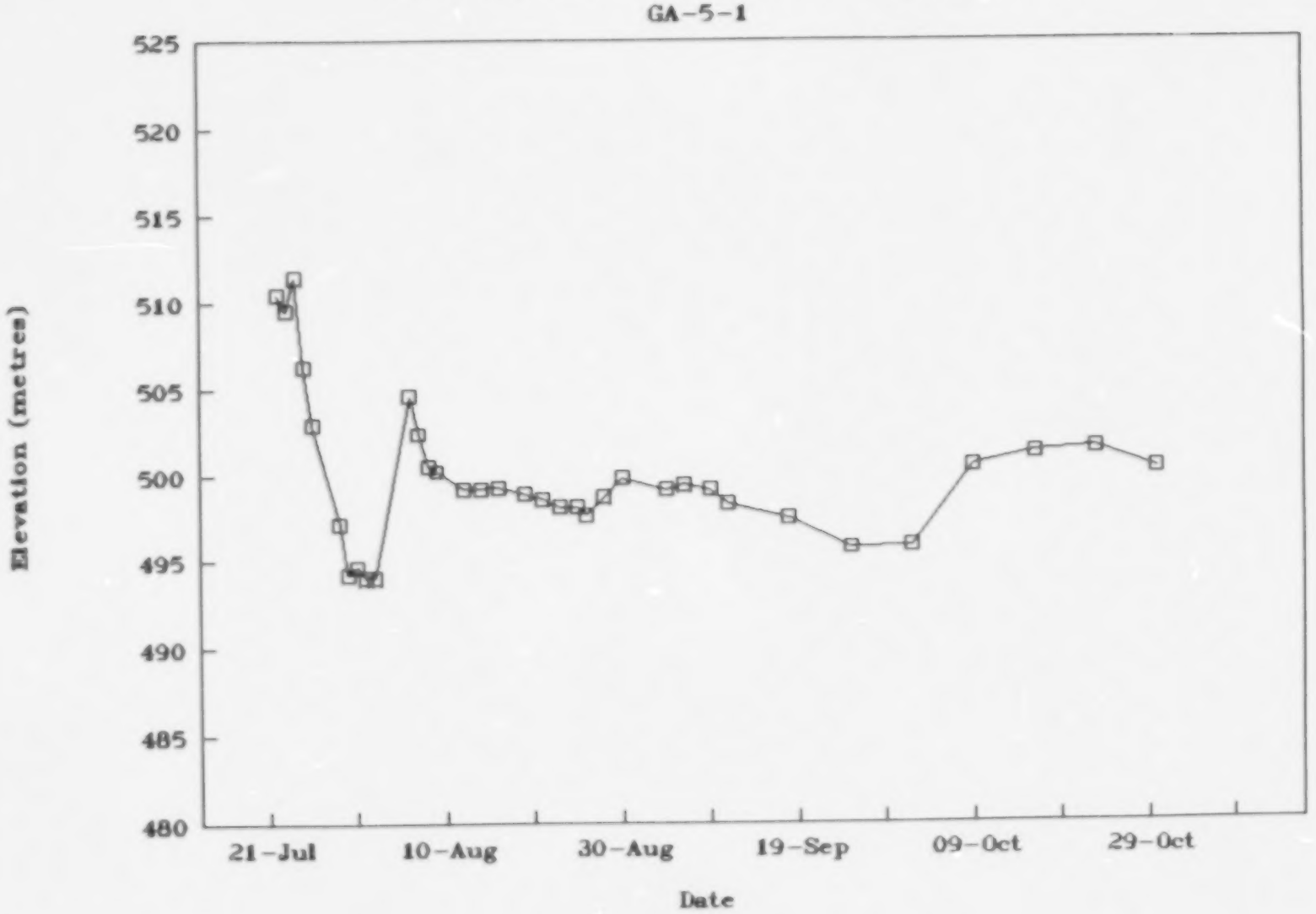


FIGURE D-5

Groundwater Elevations

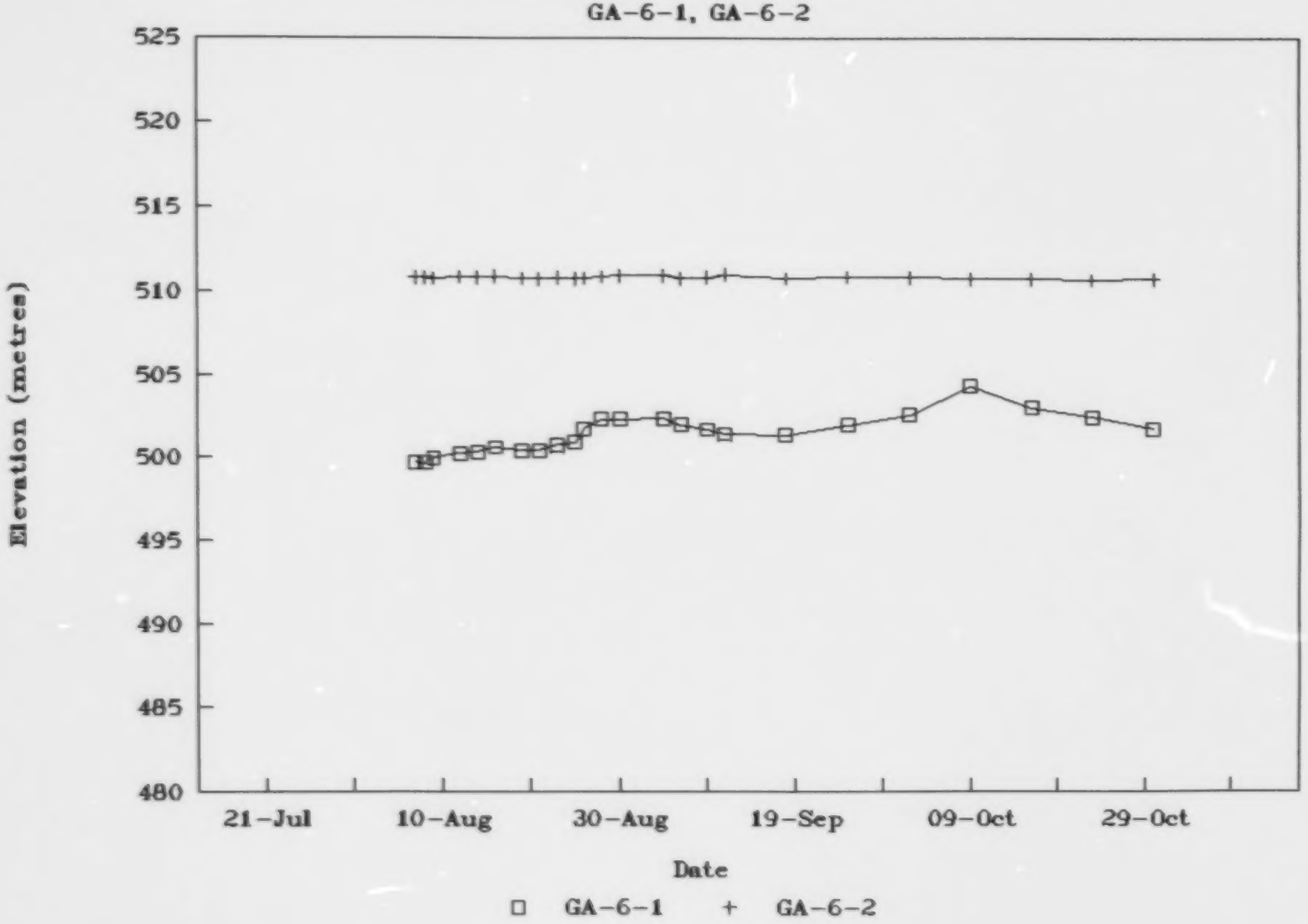


FIGURE D-6

Groundwater Elevations

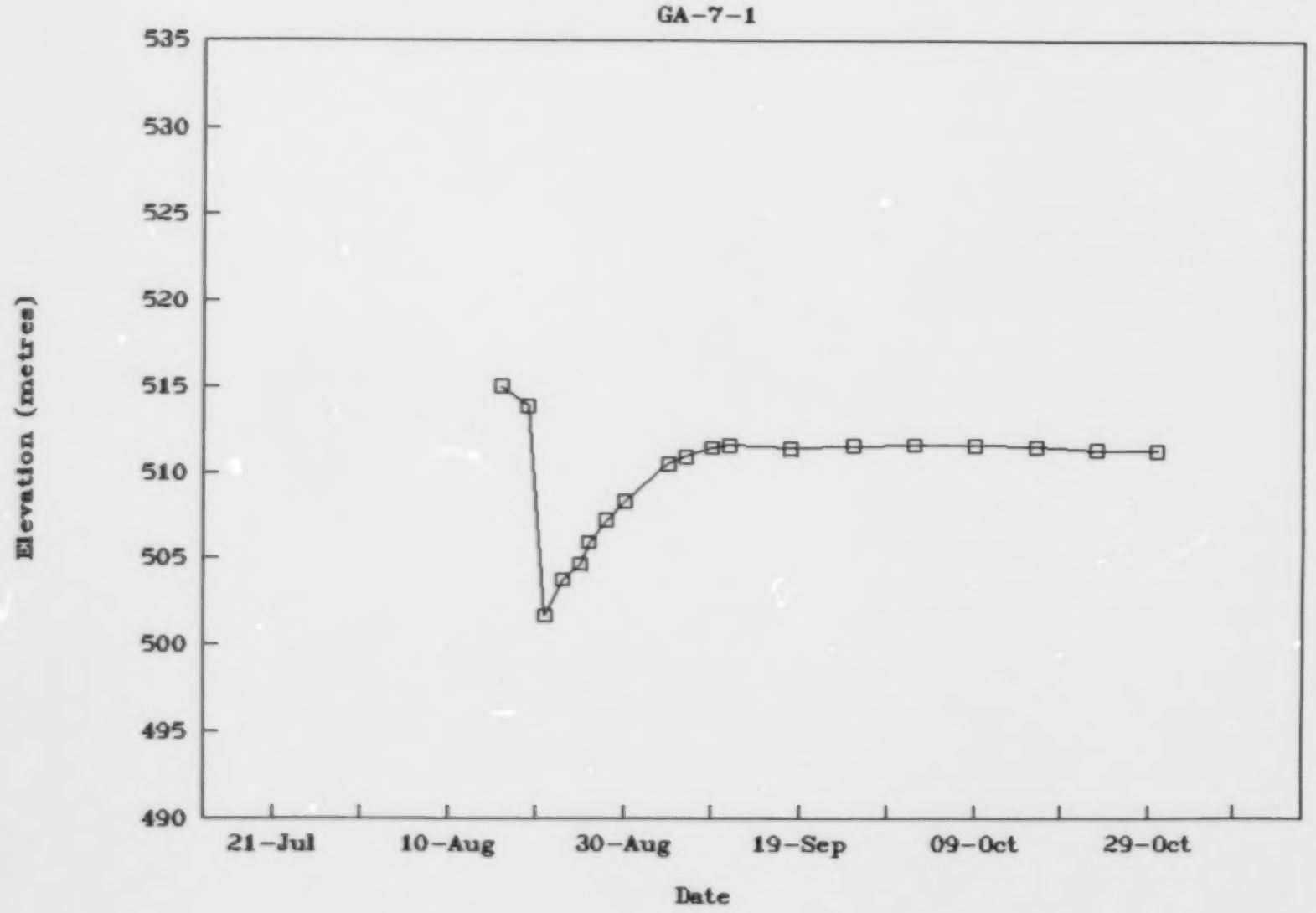


FIGURE D-7

Groundwater Elevations

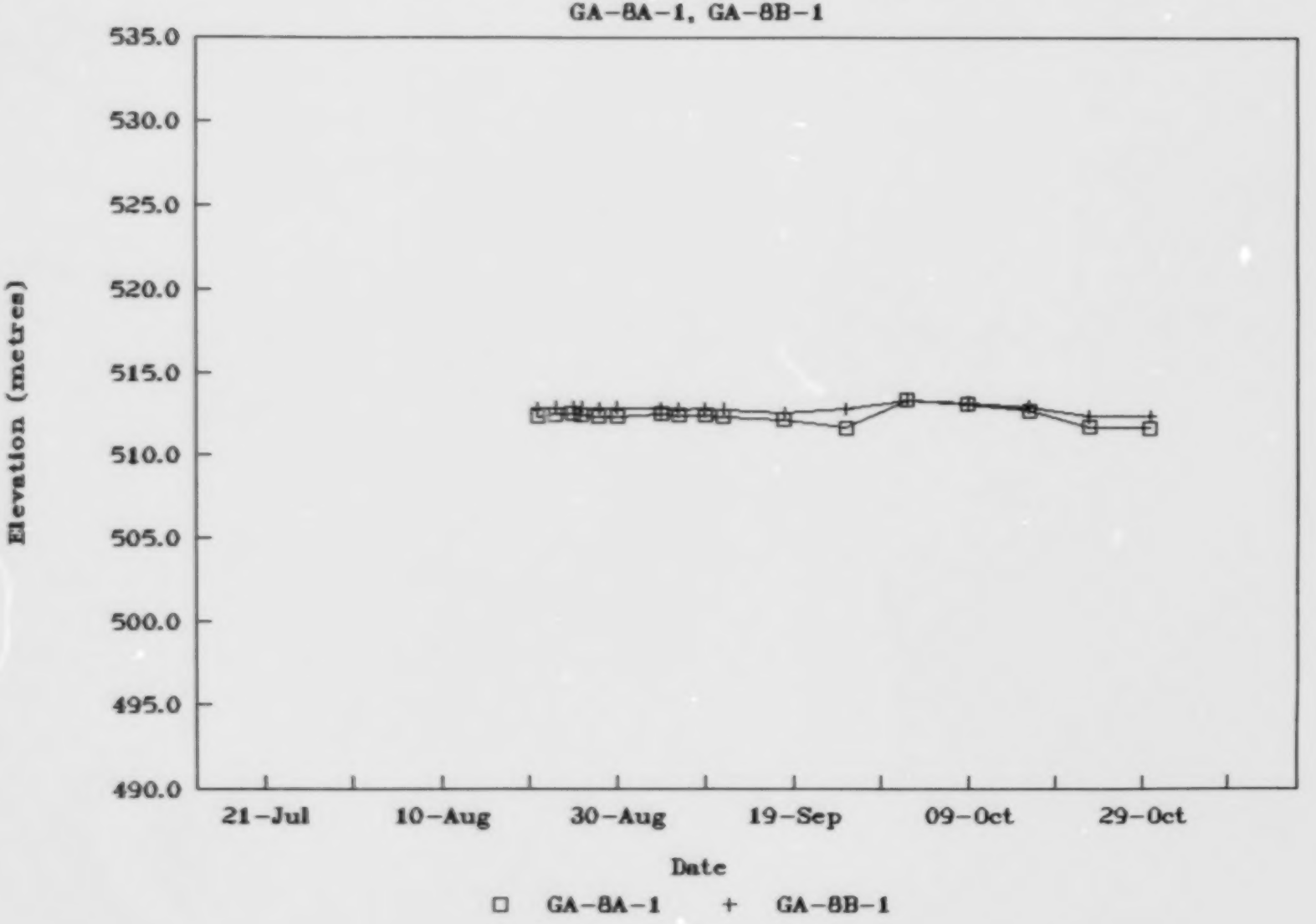


FIGURE D-8

Groundwater Elevations

GA-9A-1, GA-9B-1, GA-9B-2

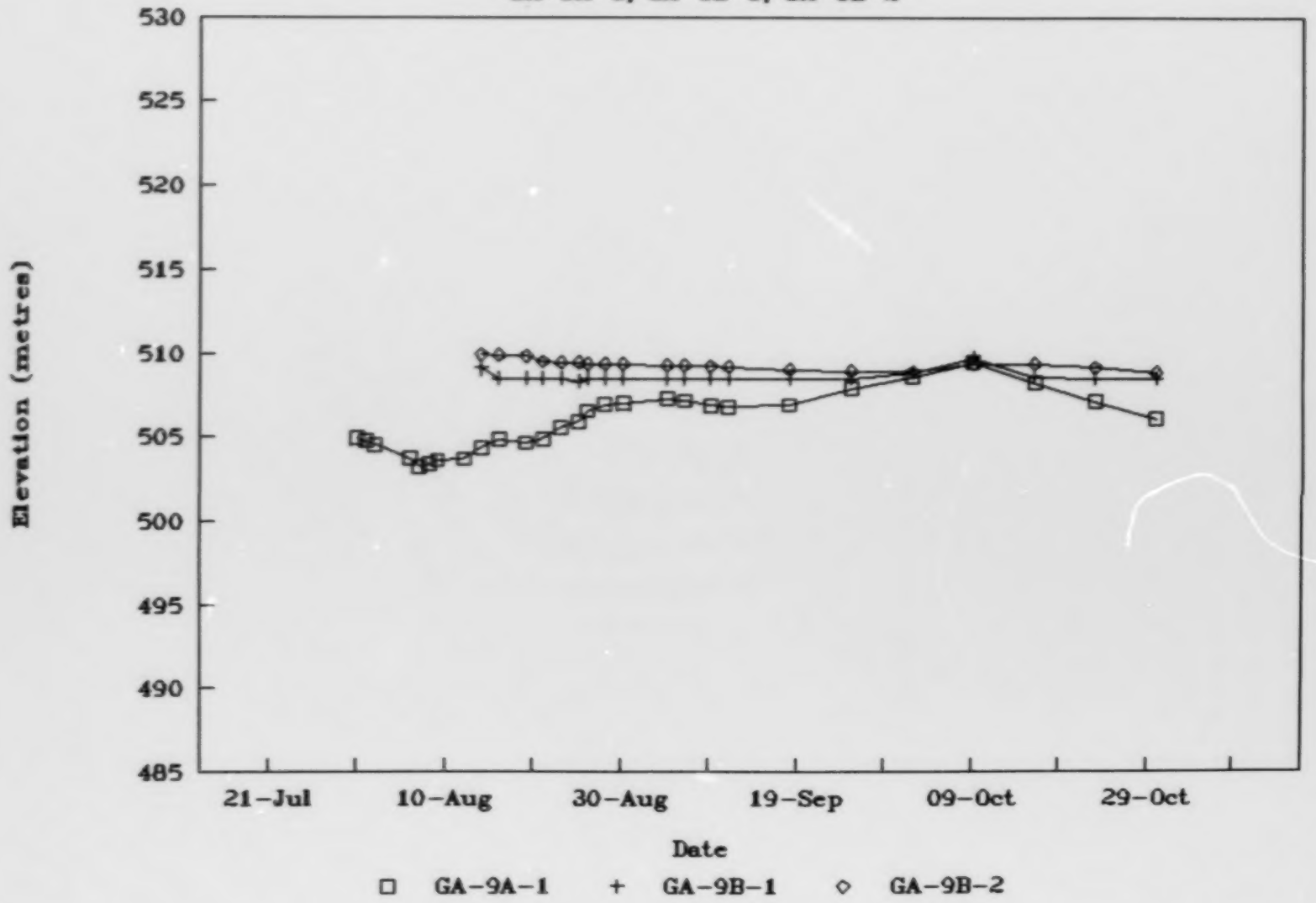


FIGURE D-9

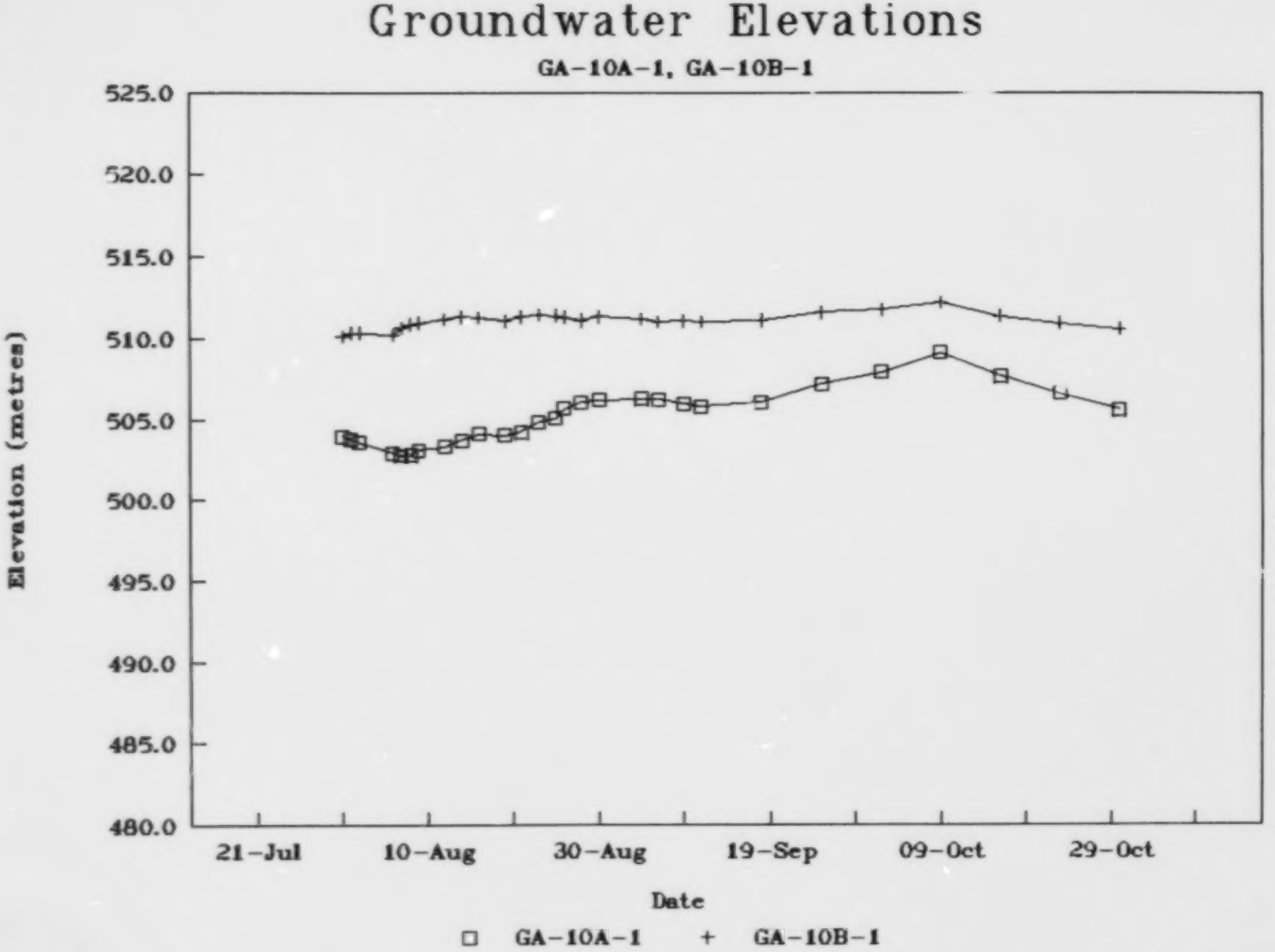

Groundwater Elevations
GA-10A-1, GA-10B-1
525.0
520.0
515.0
510.0
505.0
500.0
495.0
490.0
485.0
480.0
Elevation (metres)
21-Jul
10-Aug
30-Aug
19-Sep
09-Oct
29-Oct
Date
GA-10A-1
GA-10B-1

FIGURE D-10

Groundwater Elevations

GA-11-1, GA-11-2, GA-11-3

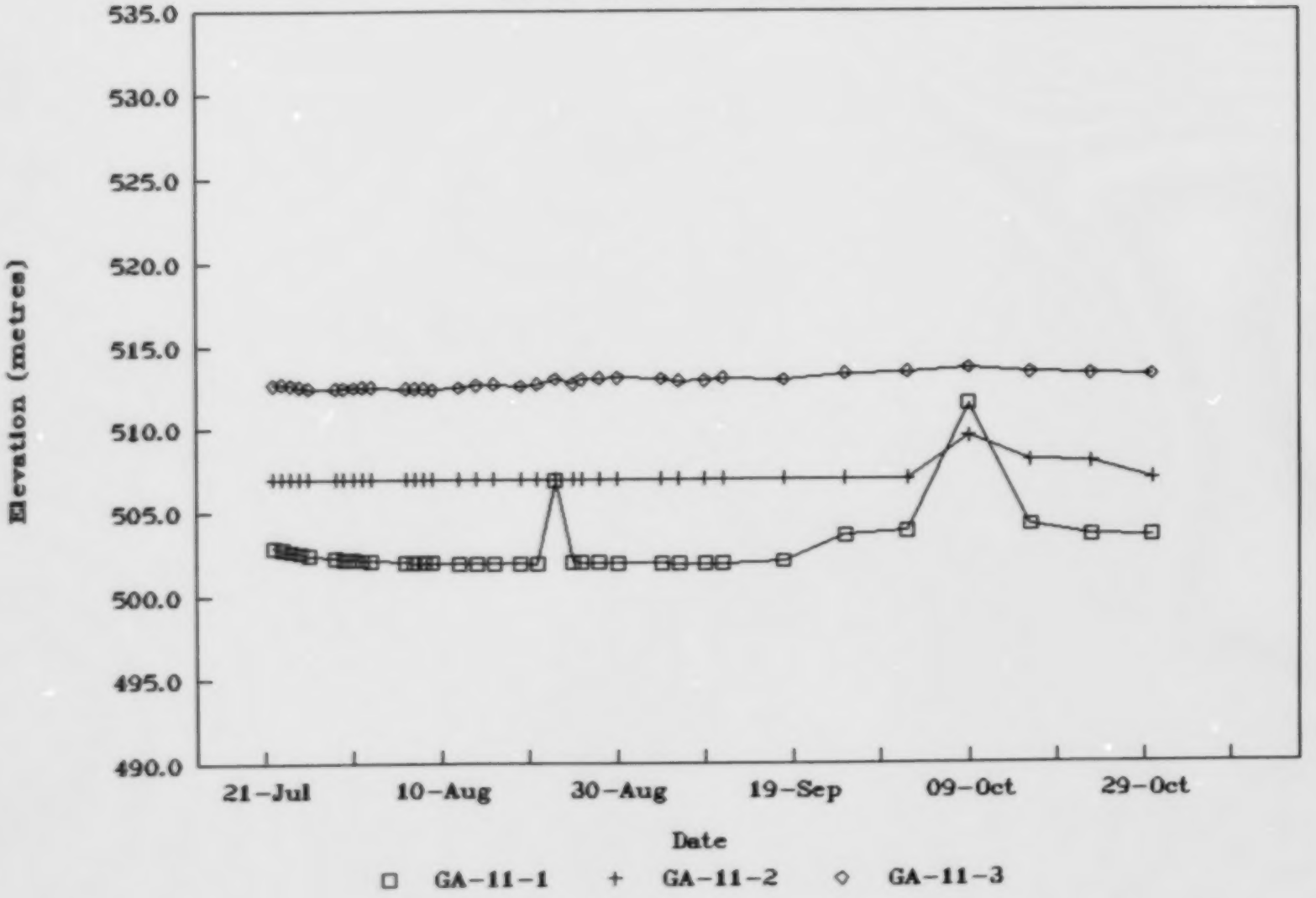


FIGURE D-11

Groundwater Elevations

GA-12-1, GA-12-2

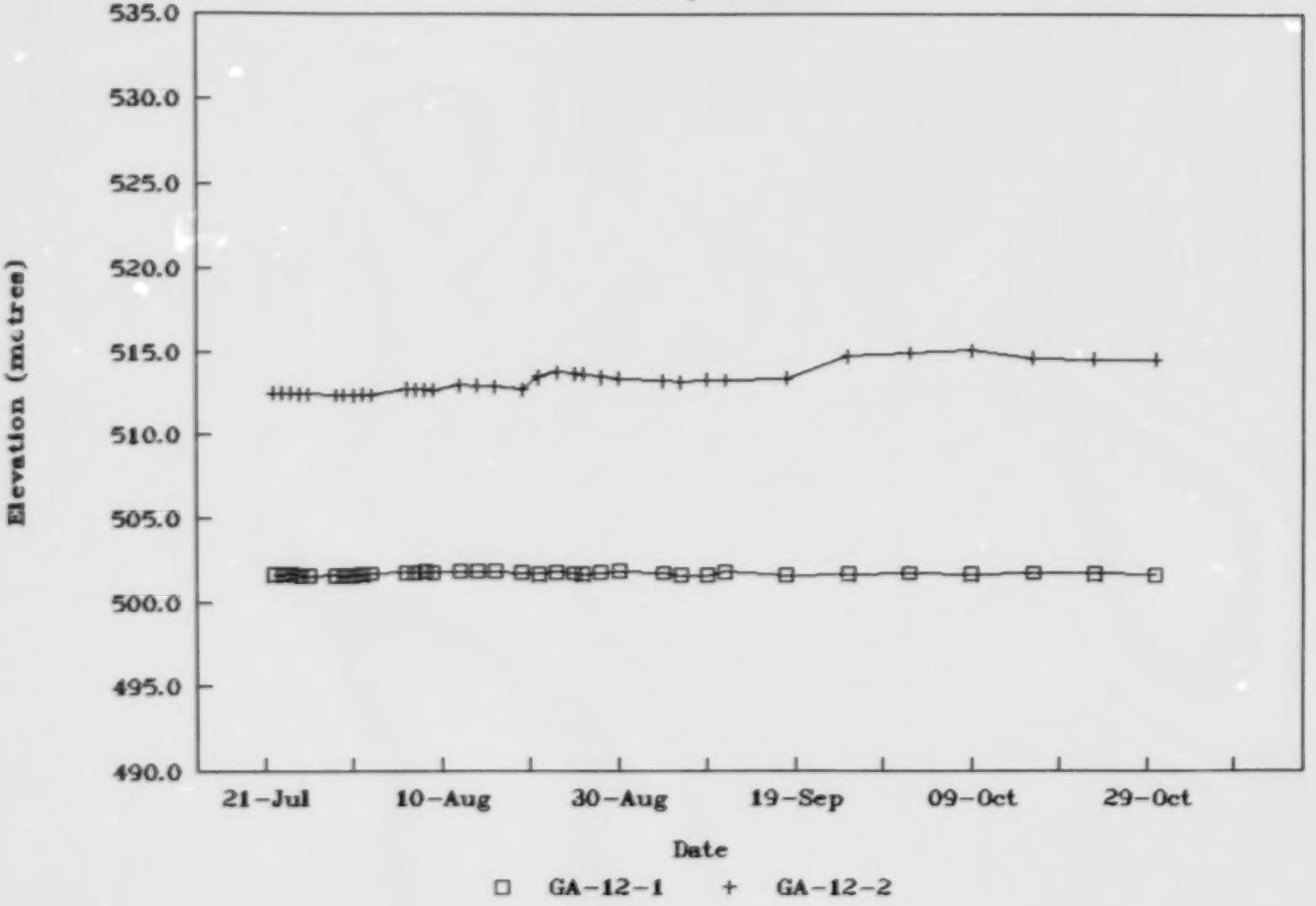


FIGURE D-12

Groundwater Elevations

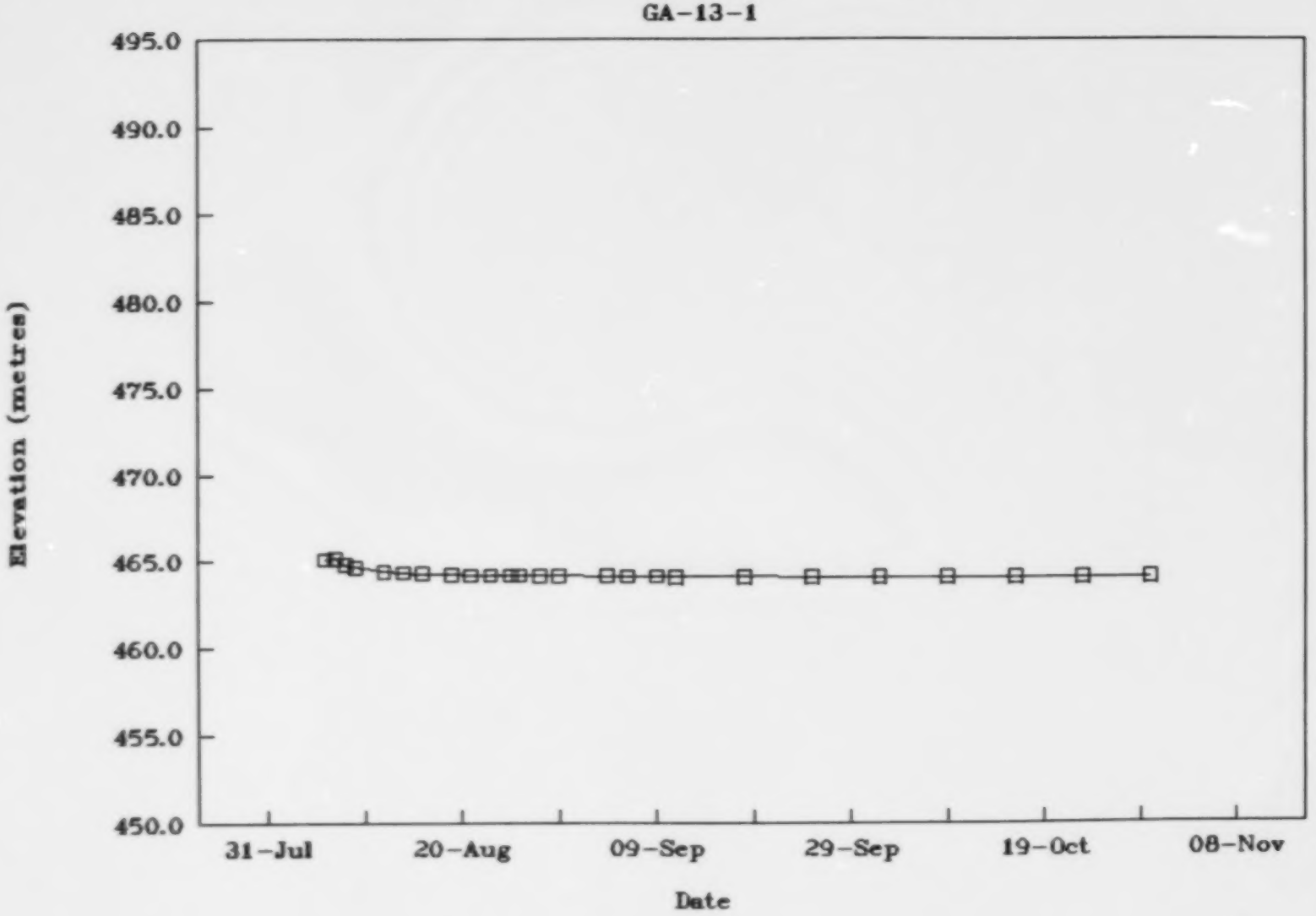


FIGURE D-13

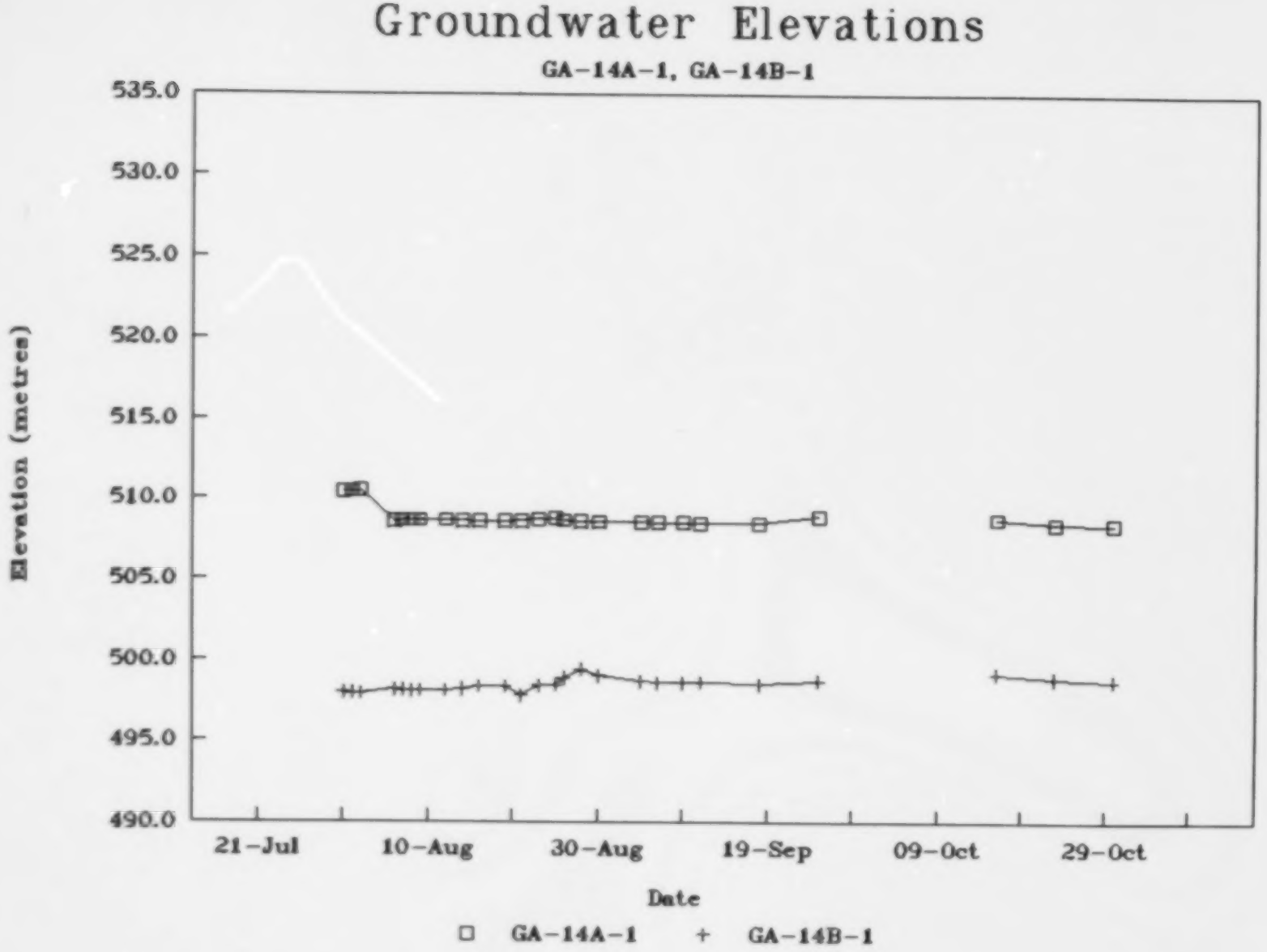

Groundwater Elevations
GA-14A-1, GA-14B-1
535.0
530.0
525.0
520.0
515.0
510.0
505.0
500.0
495.0
490.0
Elevation (metres)
21-Jul
10-Aug
30-Aug
19-Sep
09-Oct
29-Oct
Date
GA-14A-1
GA-14B-1

FIGURE D-14

Groundwater Elevations

GA-15-1, GA-15-2, GA-15-3

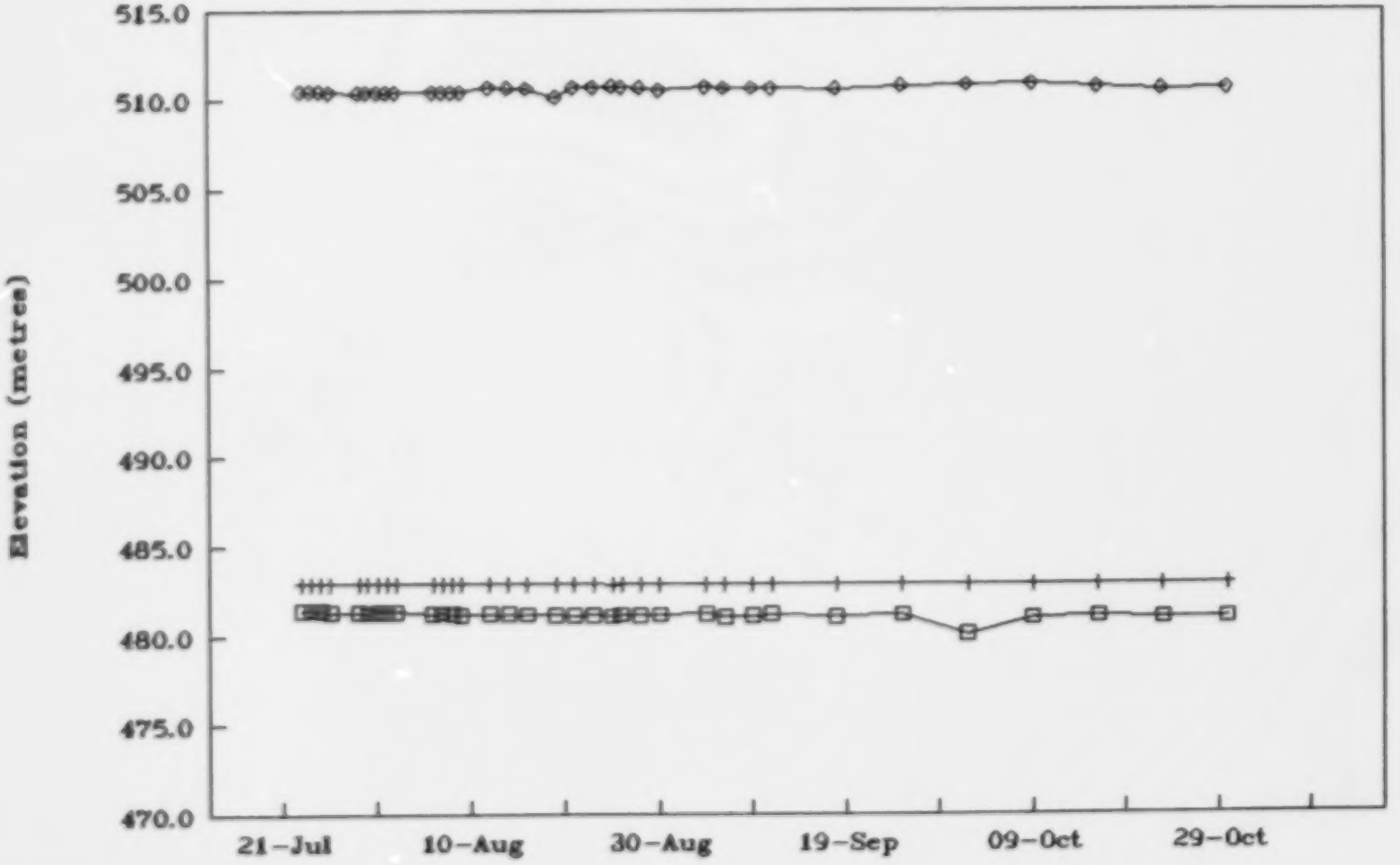


FIGURE D-15

Groundwater Elevations

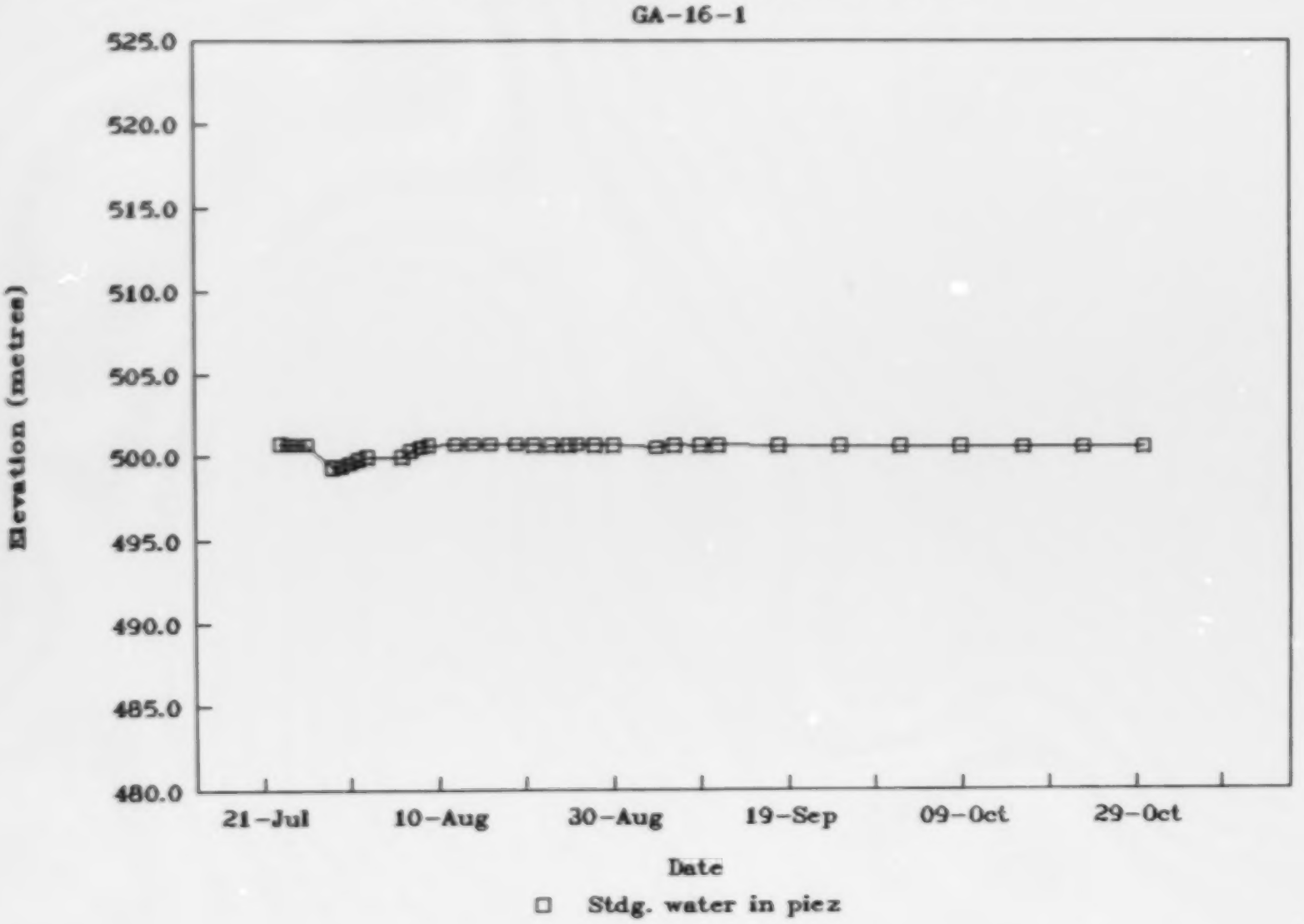


FIGURE D-16

Groundwater Elevations

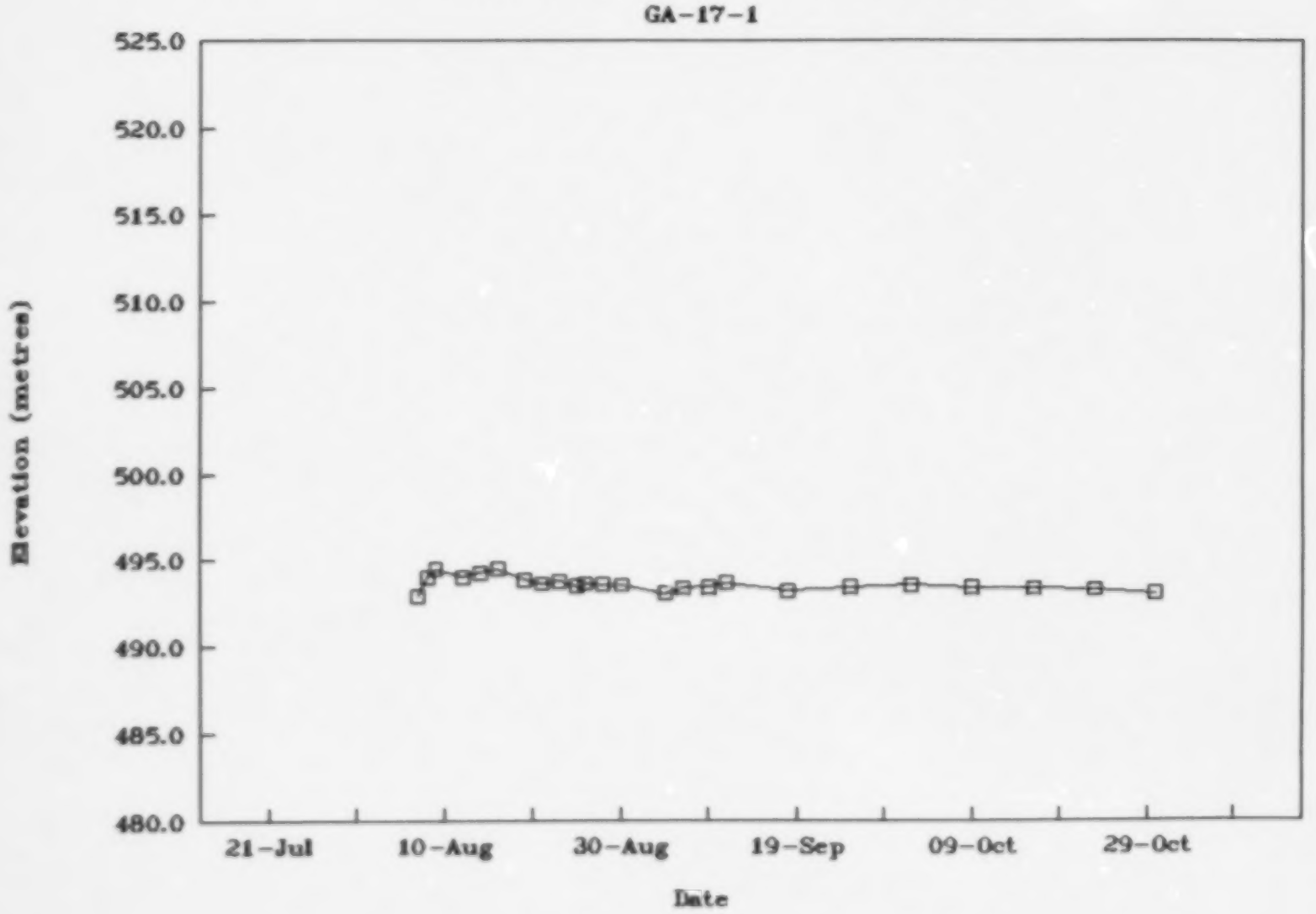


FIGURE D-17

Groundwater Elevations

GA-18-1, GA-18-2

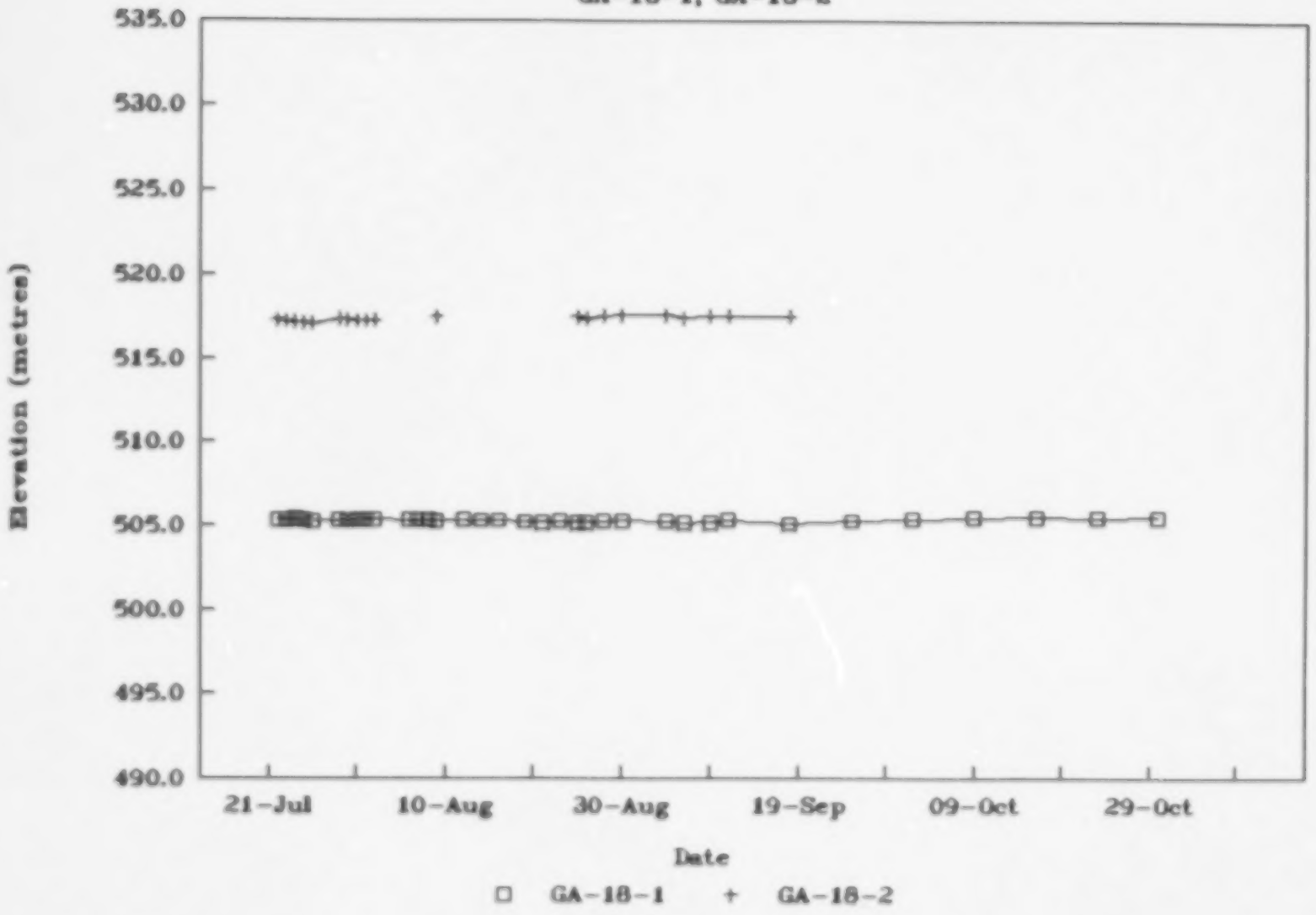


FIGURE D-18

Groundwater Elevations

GA-19-1, GA-19-2, GA-19-3

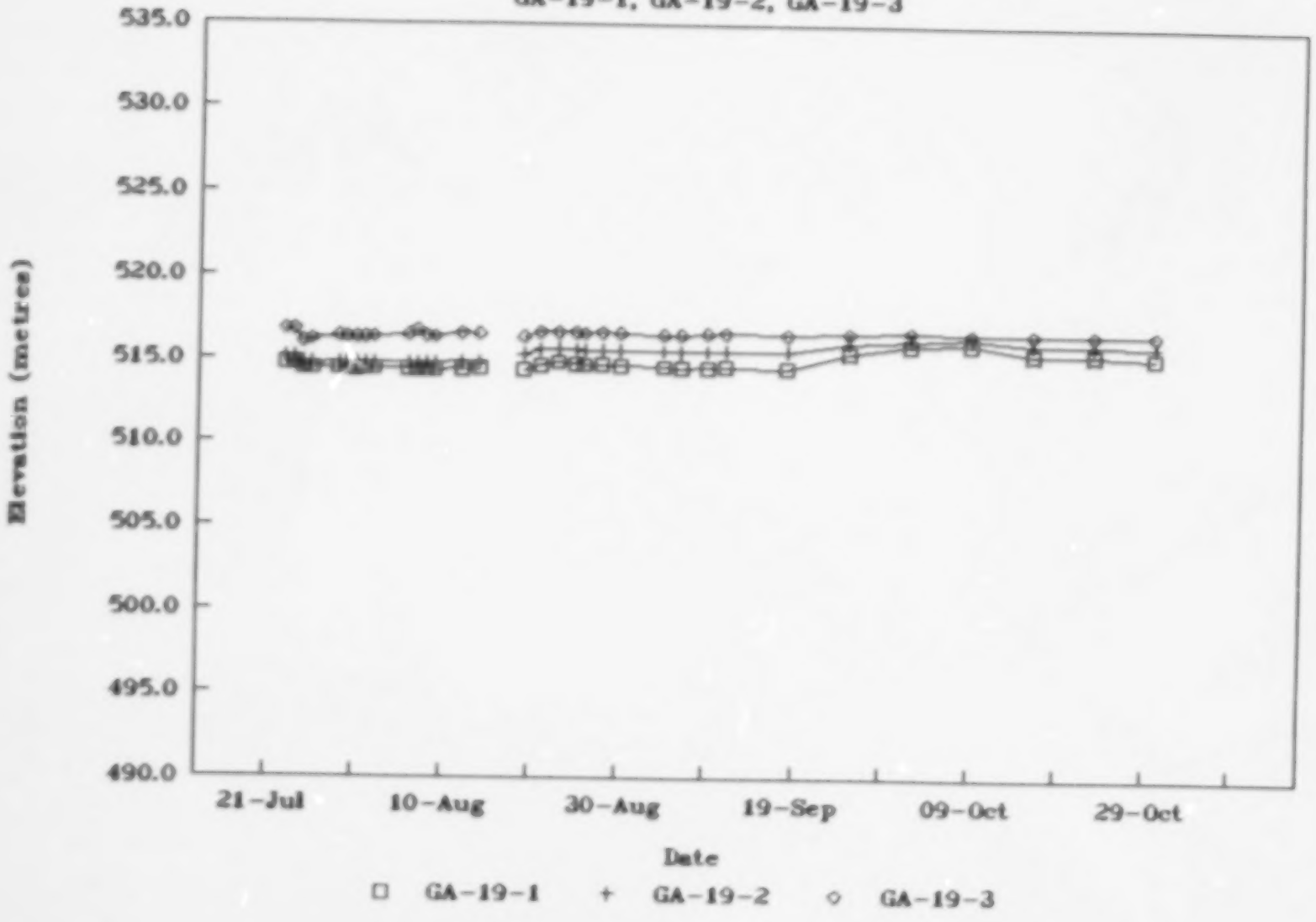


FIGURE D-19

Groundwater Elevations

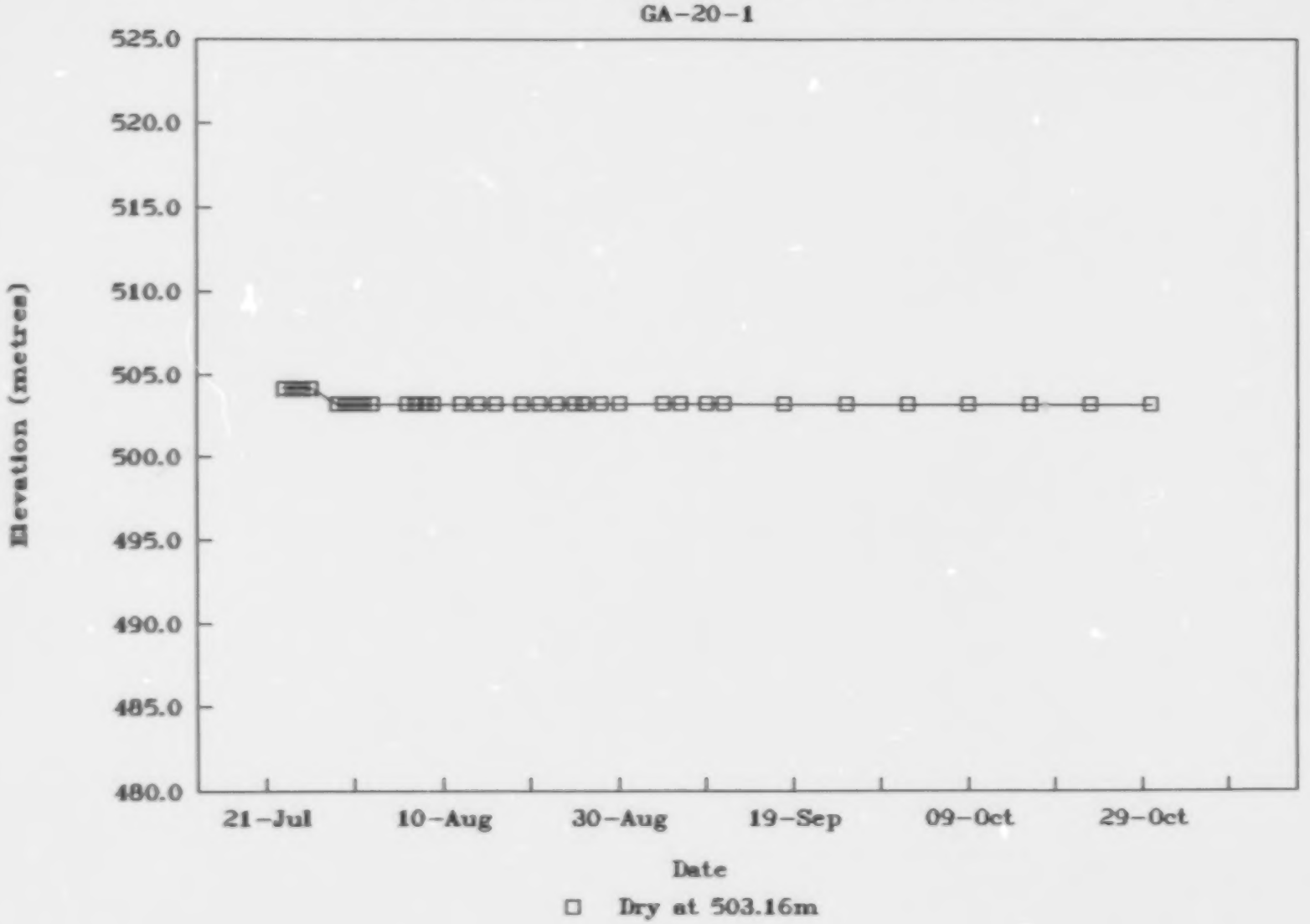


FIGURE D-20

Groundwater Elevations

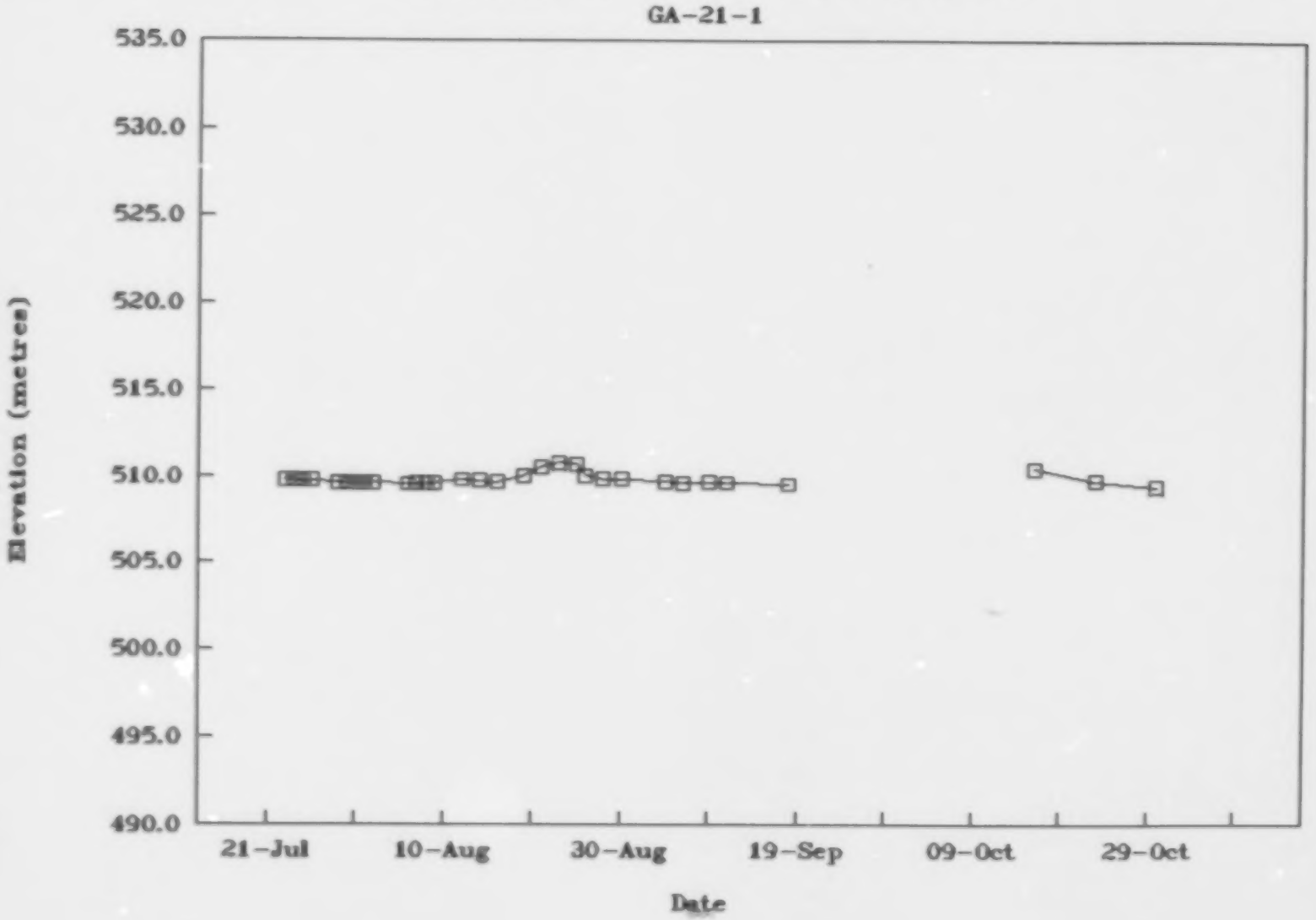


FIGURE D-21

Groundwater Elevations

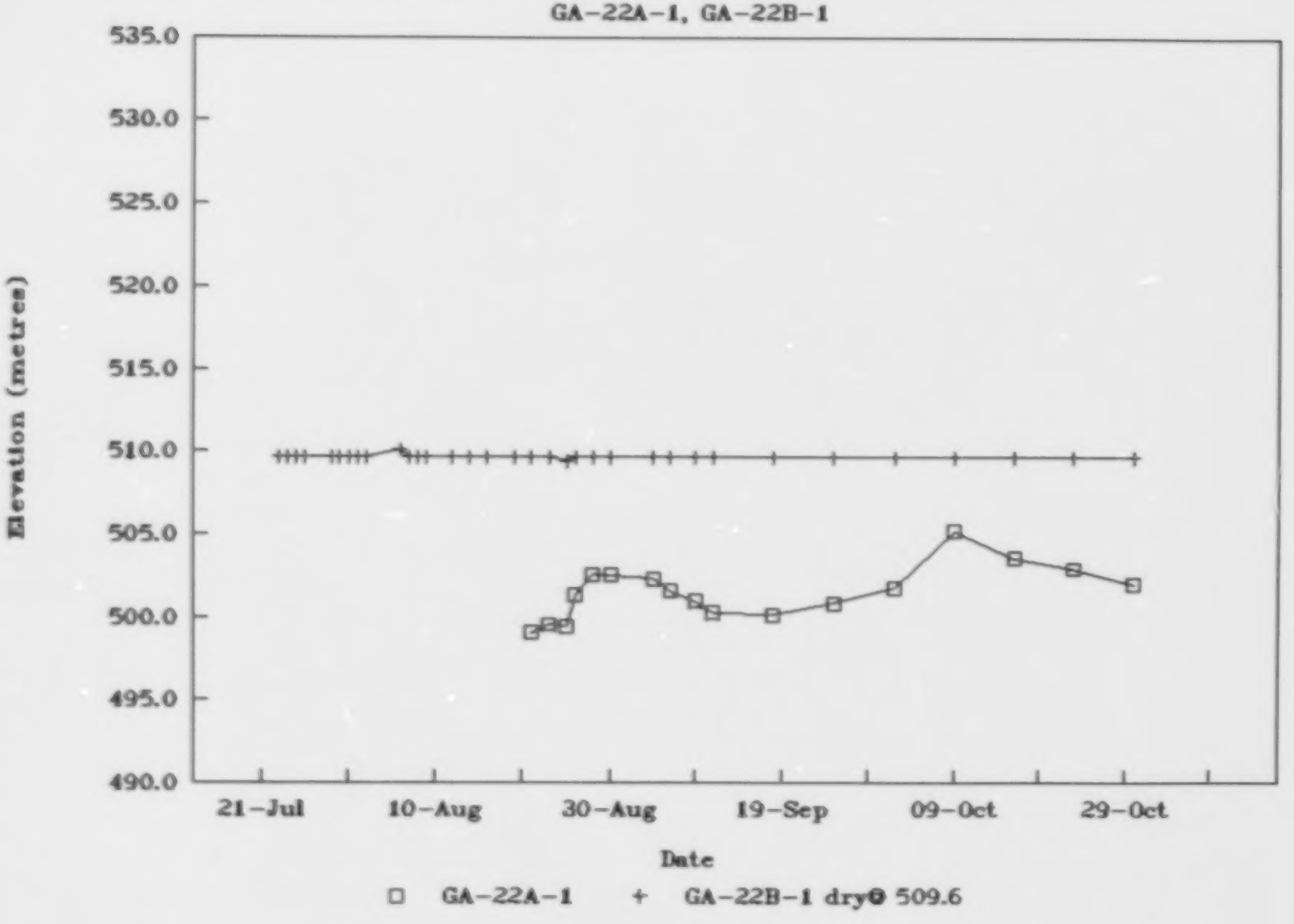


FIGURE D-22

Groundwater Elevations

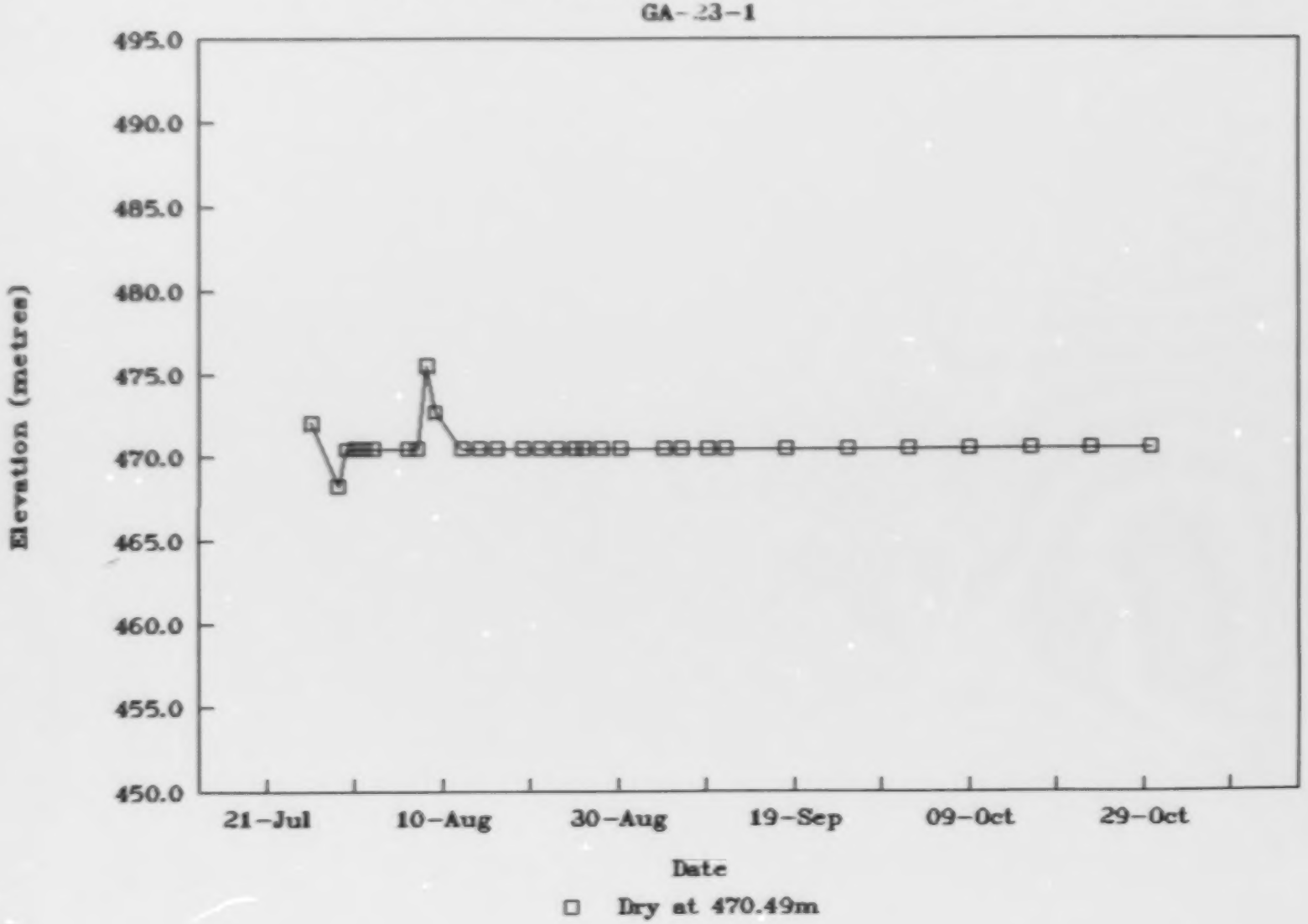


FIGURE D-23

Groundwater Elevations

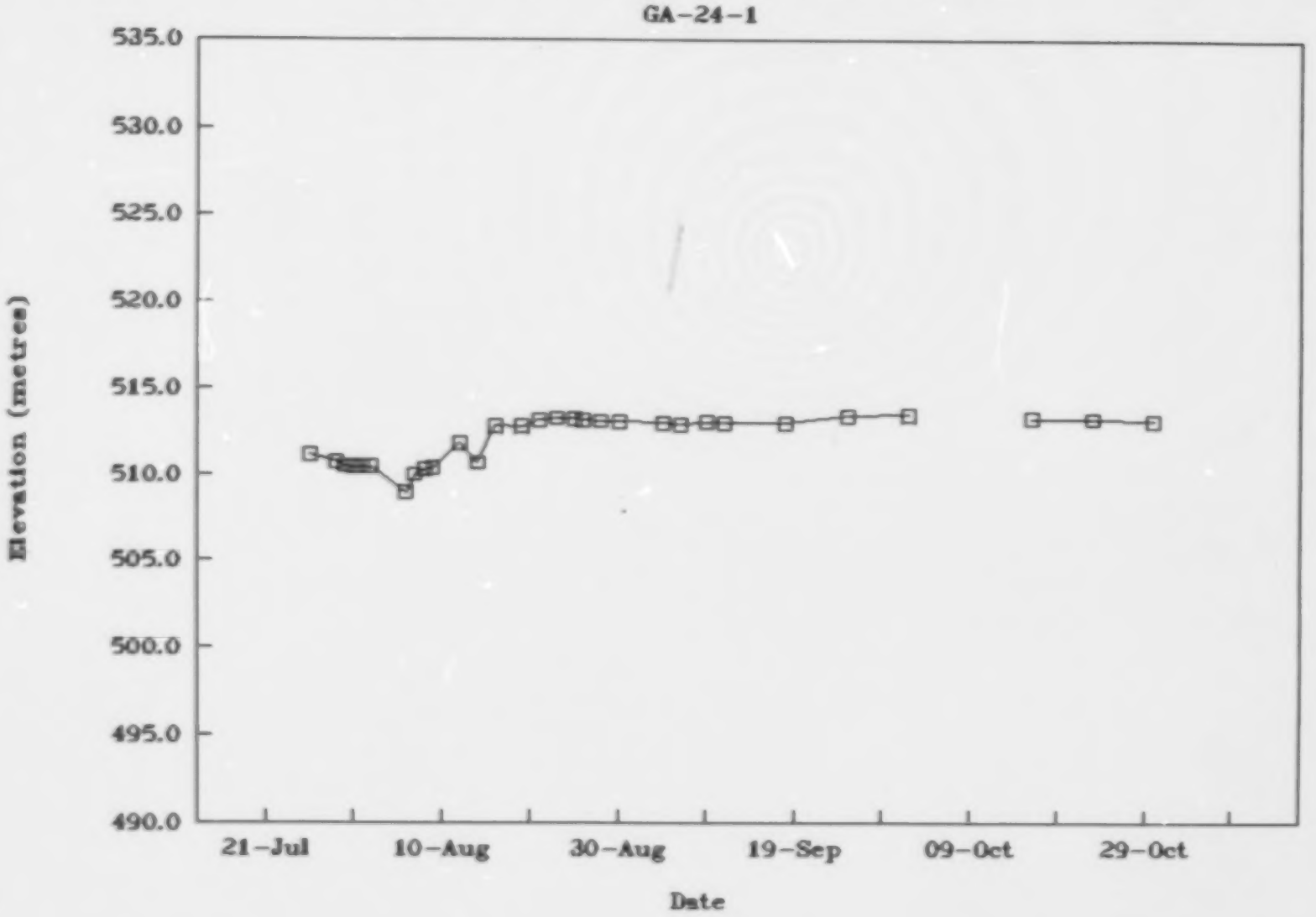


FIGURE D-24

Groundwater Elevations

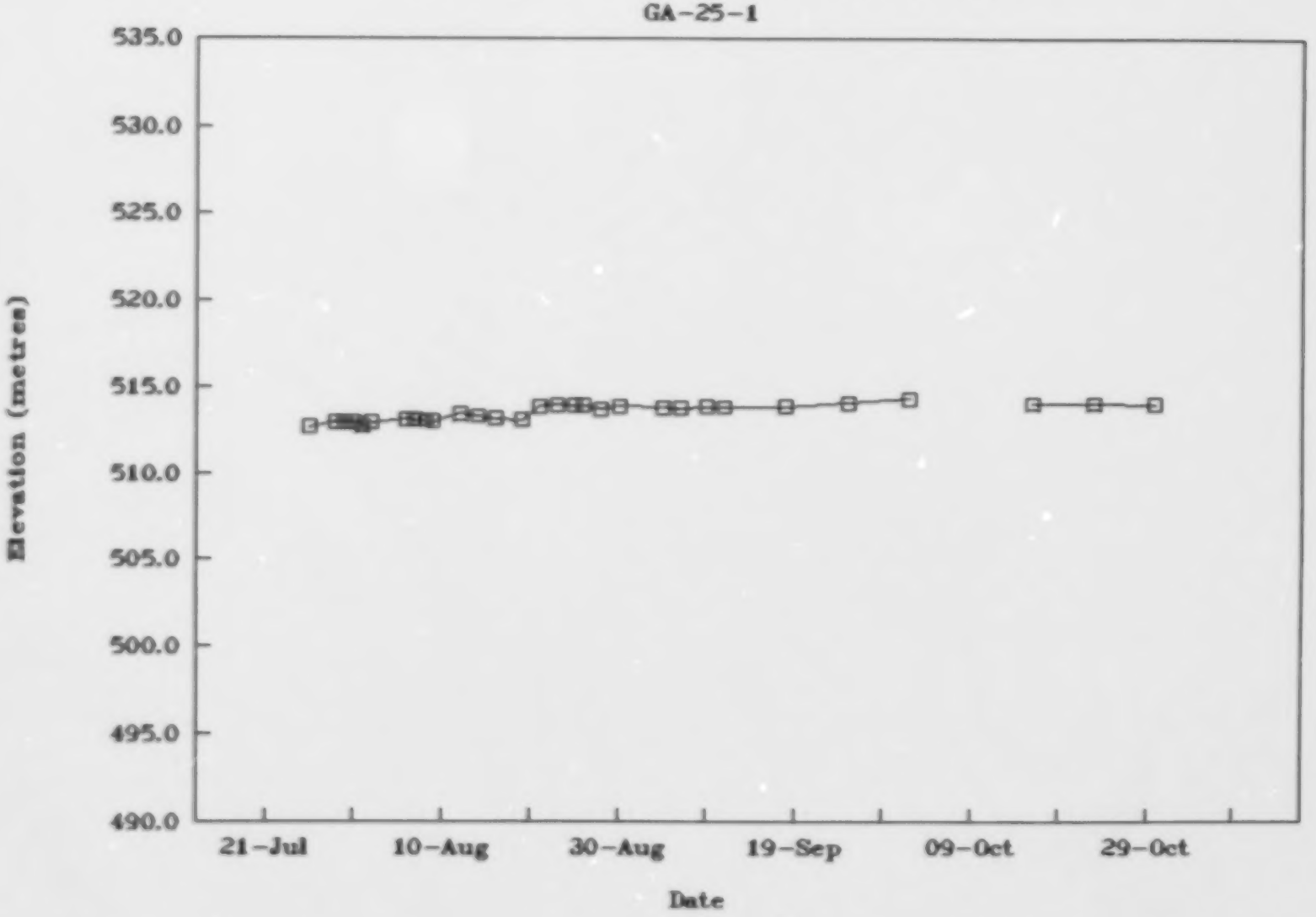


FIGURE D-25

Groundwater Elevations

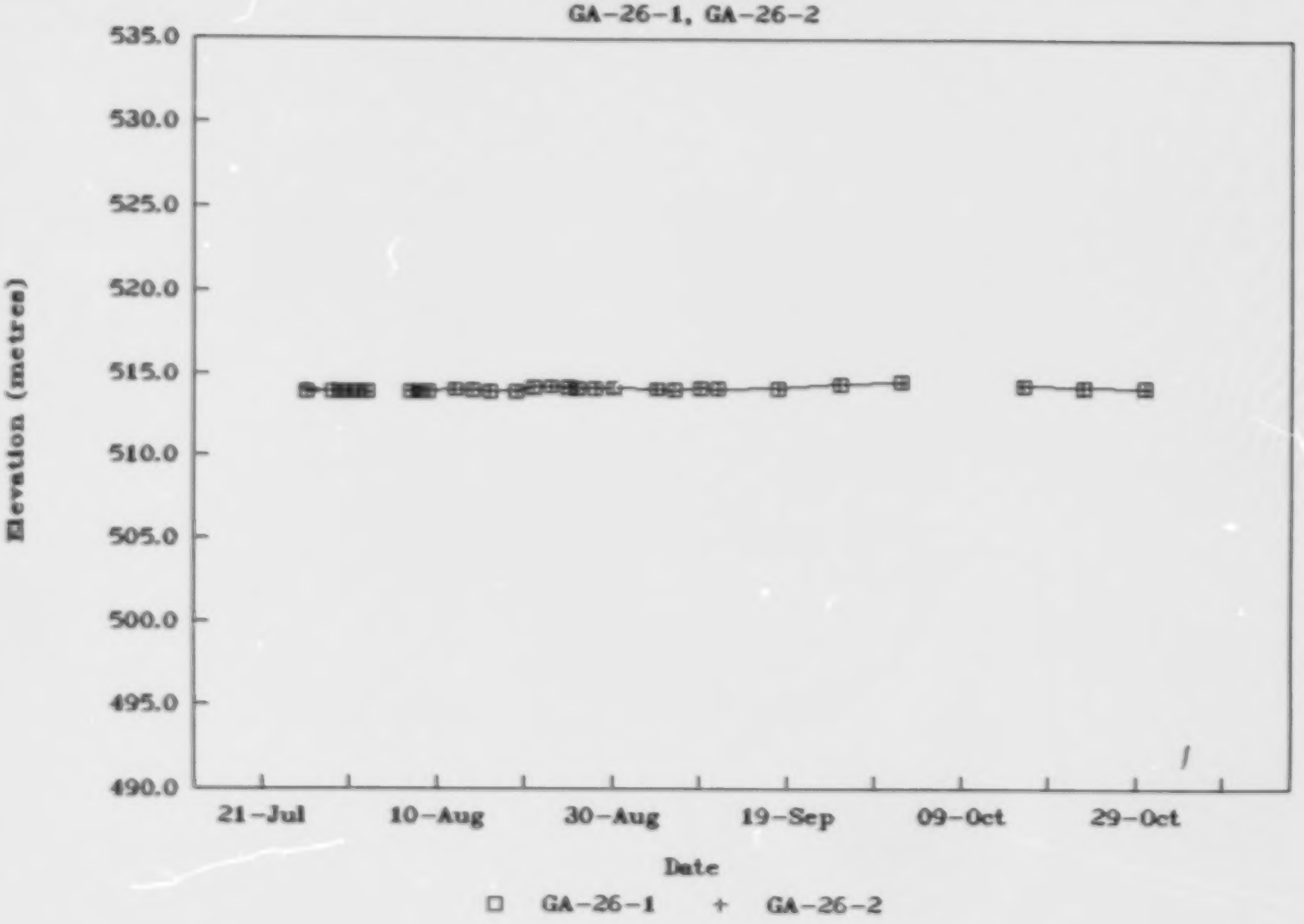


FIGURE D-26

Groundwater Elevations

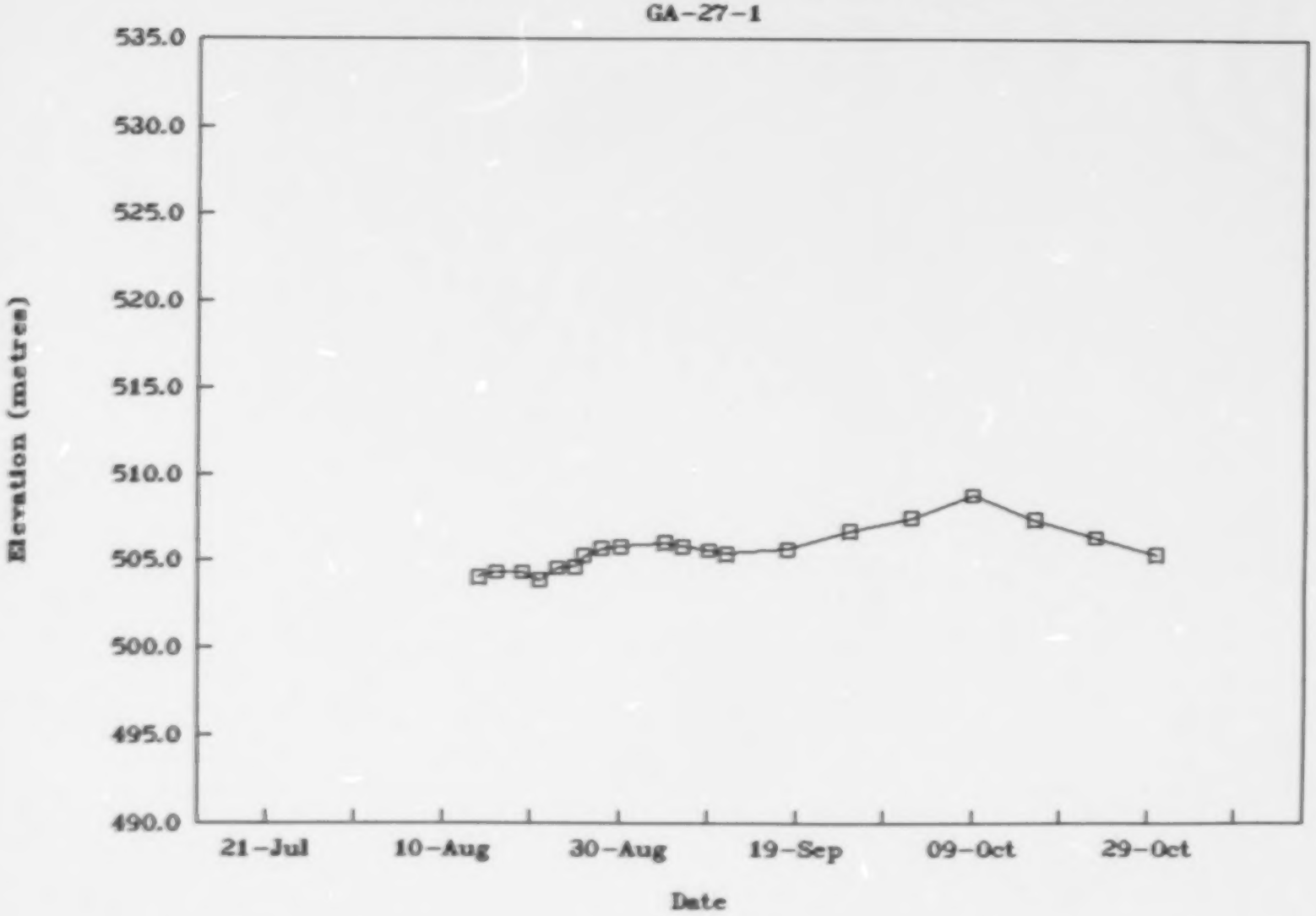


FIGURE D-27

Groundwater Elevations

GA-28A-1, GA-28B-1

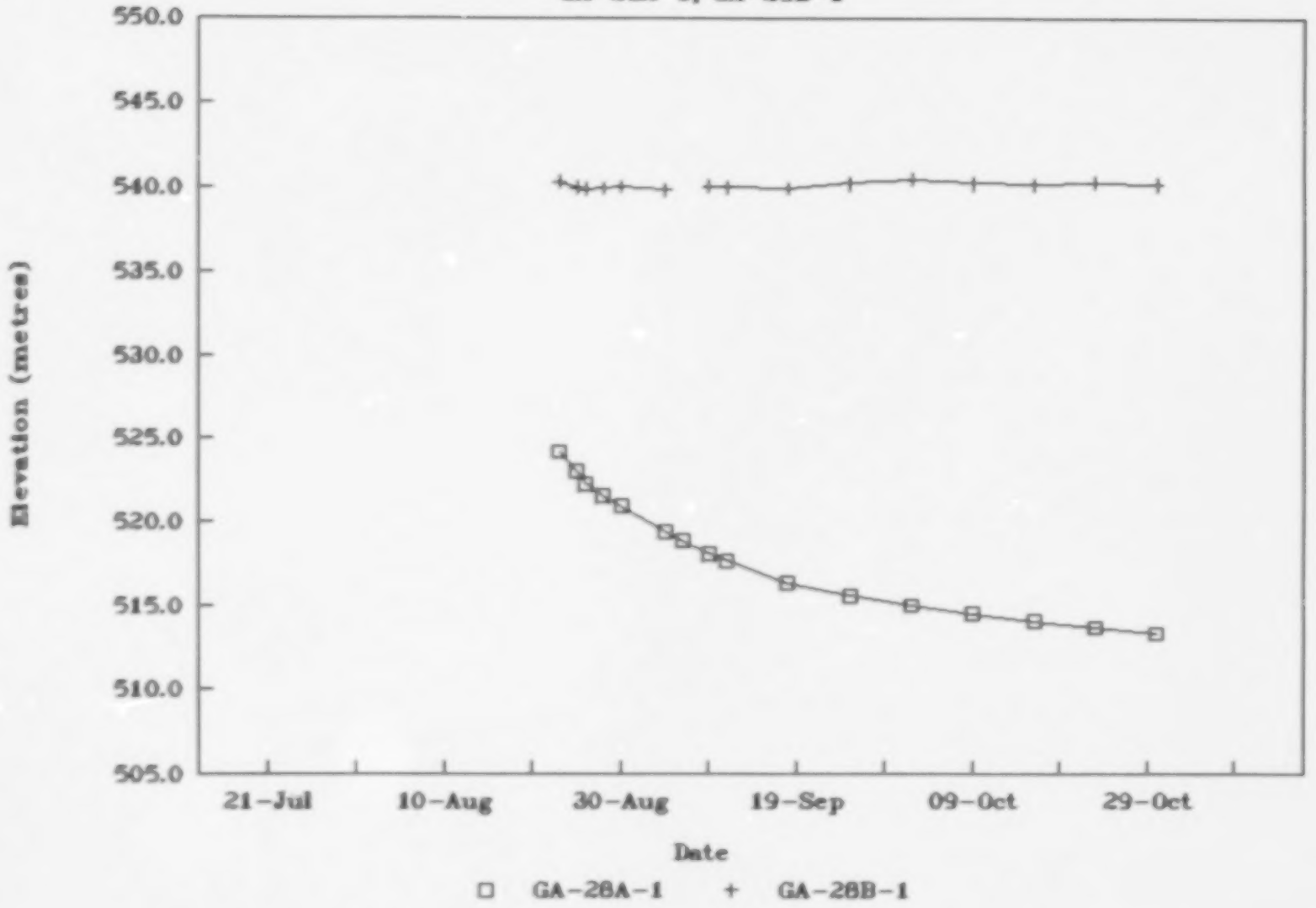


FIGURE D-28

Groundwater Elevations

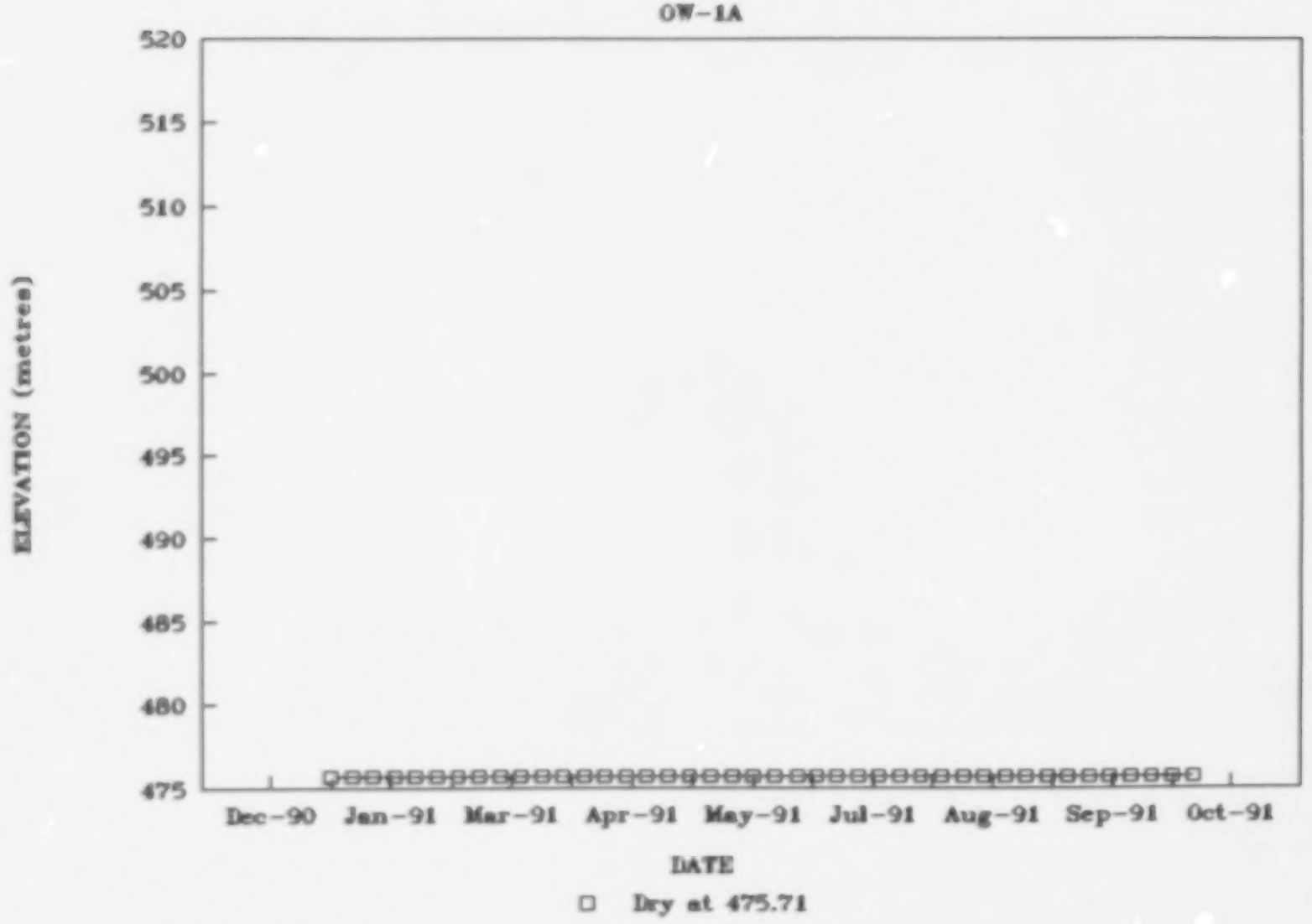


FIGURE D-29

Groundwater Elevations

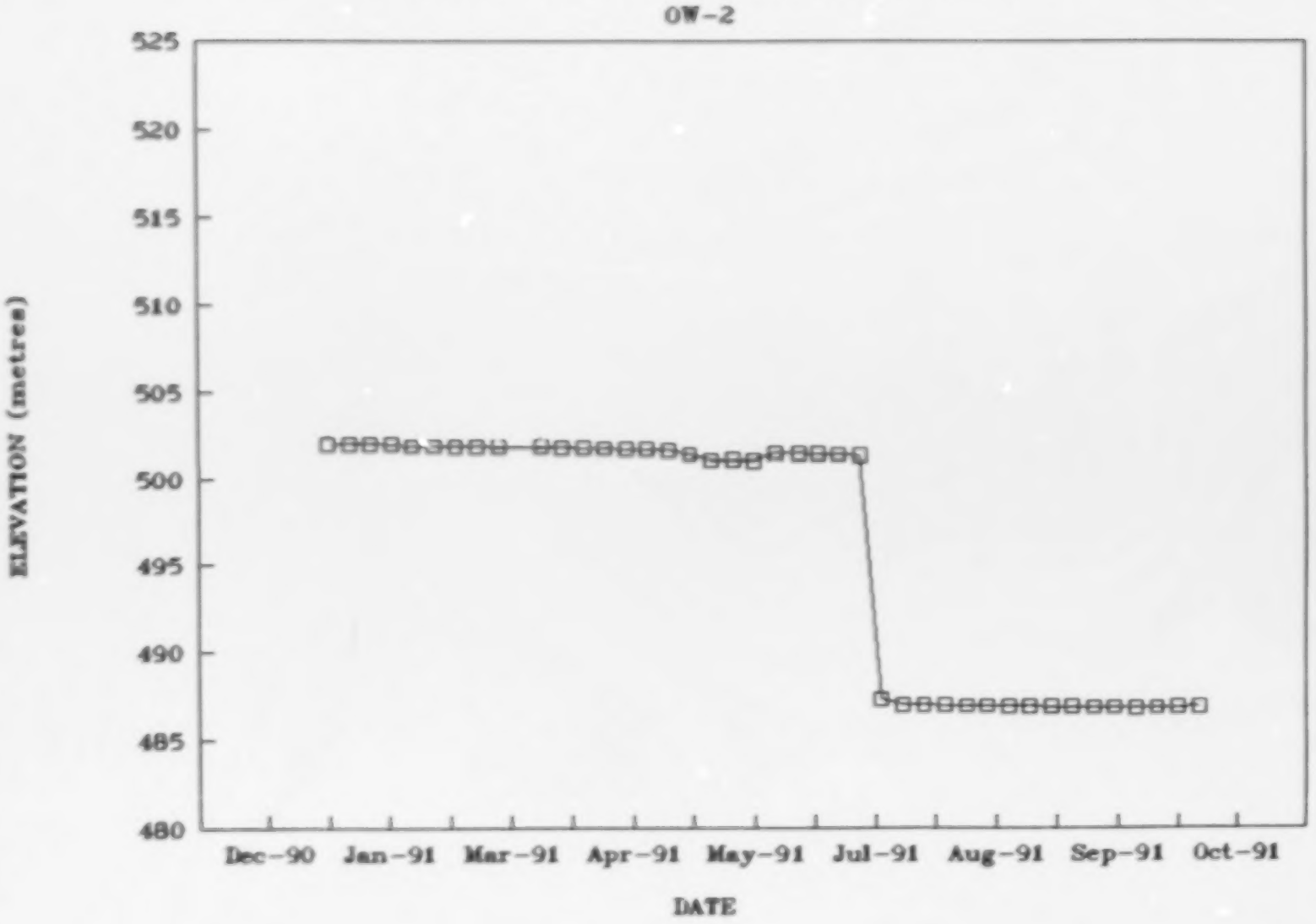


FIGURE D-30

Groundwater Elevations

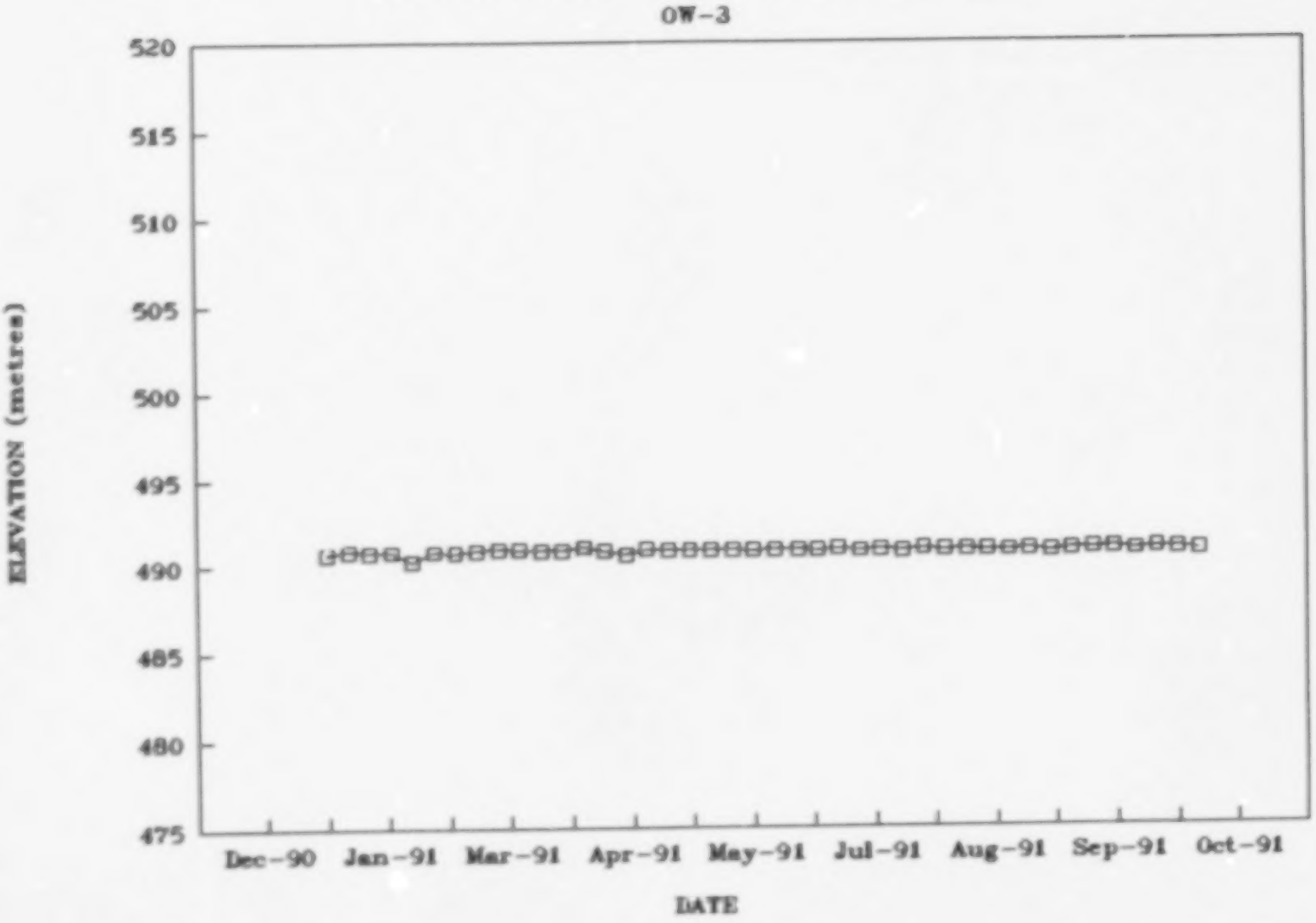


FIGURE D-31

Groundwater Elevations

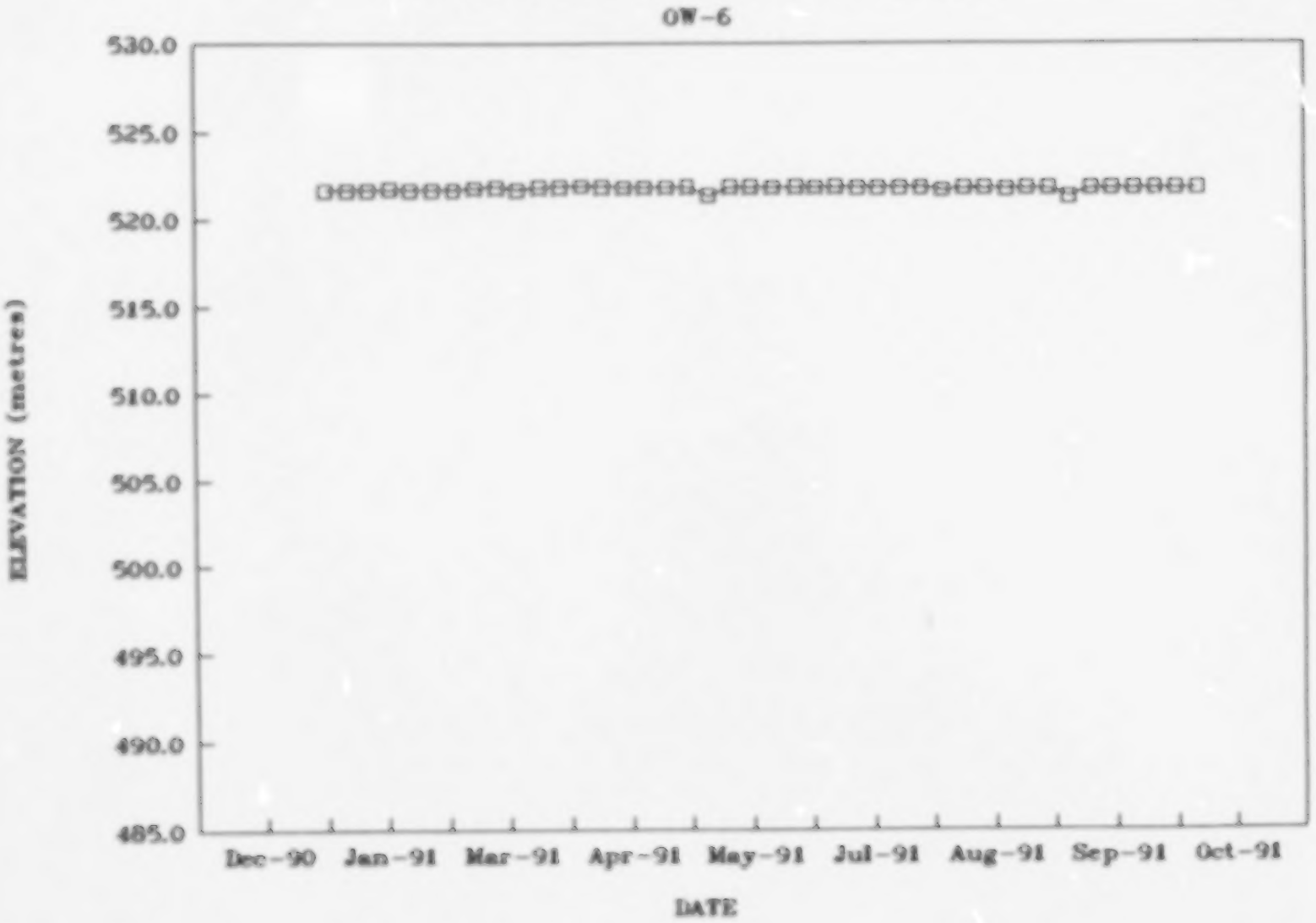


FIGURE D-32

Groundwater Elevations

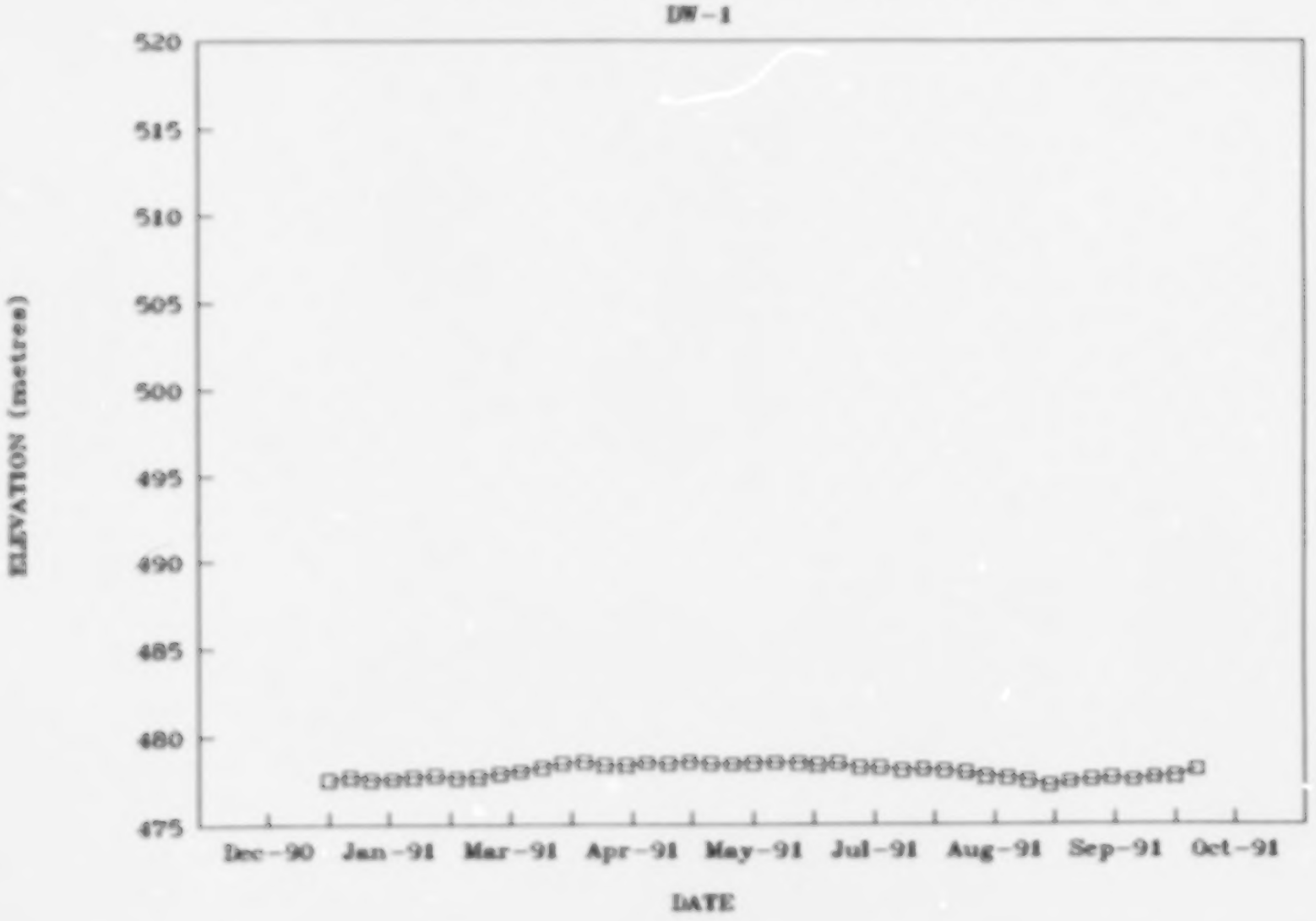


FIGURE D-31

Groundwater Elevations

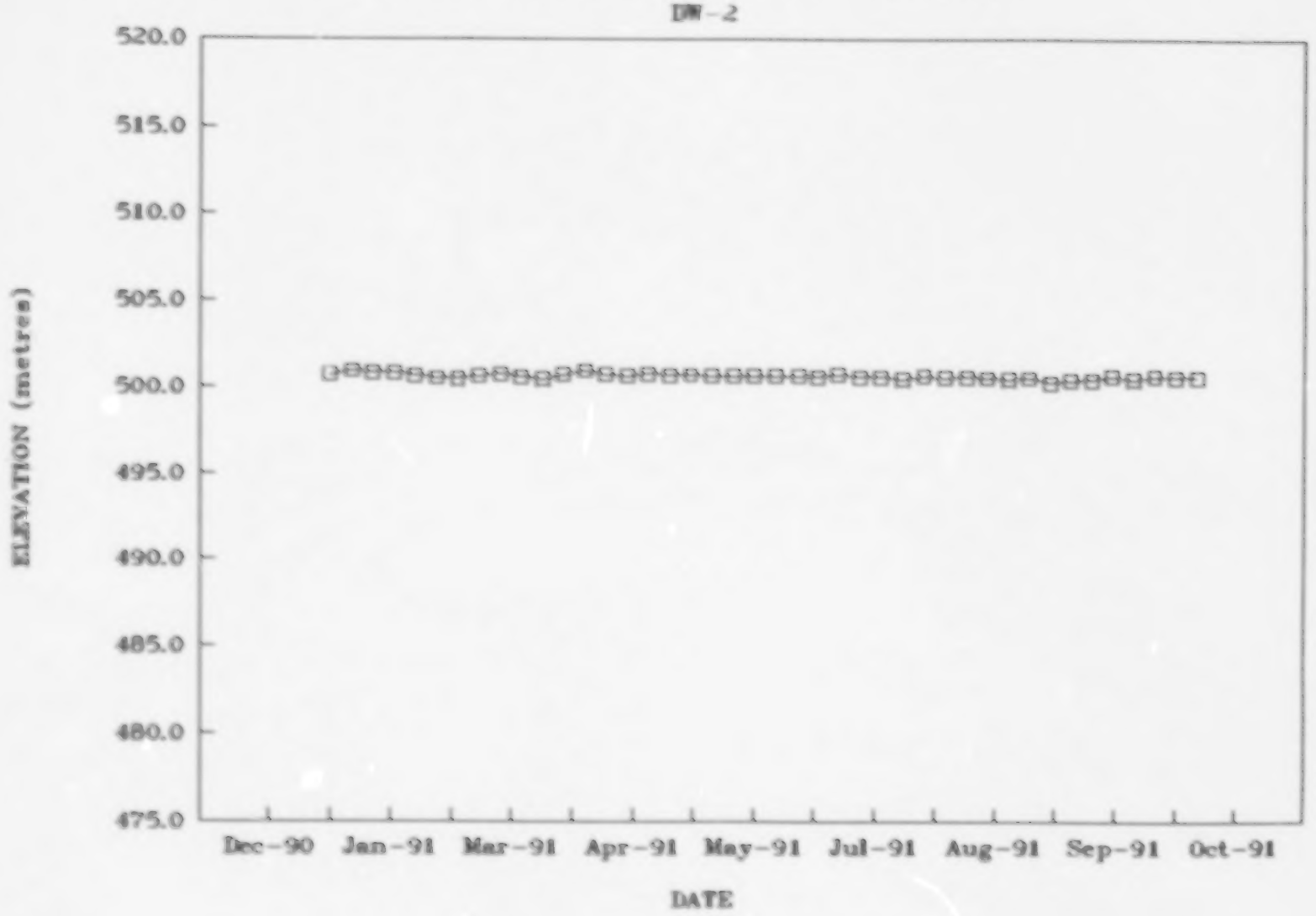


FIGURE D-34

Groundwater Elevations

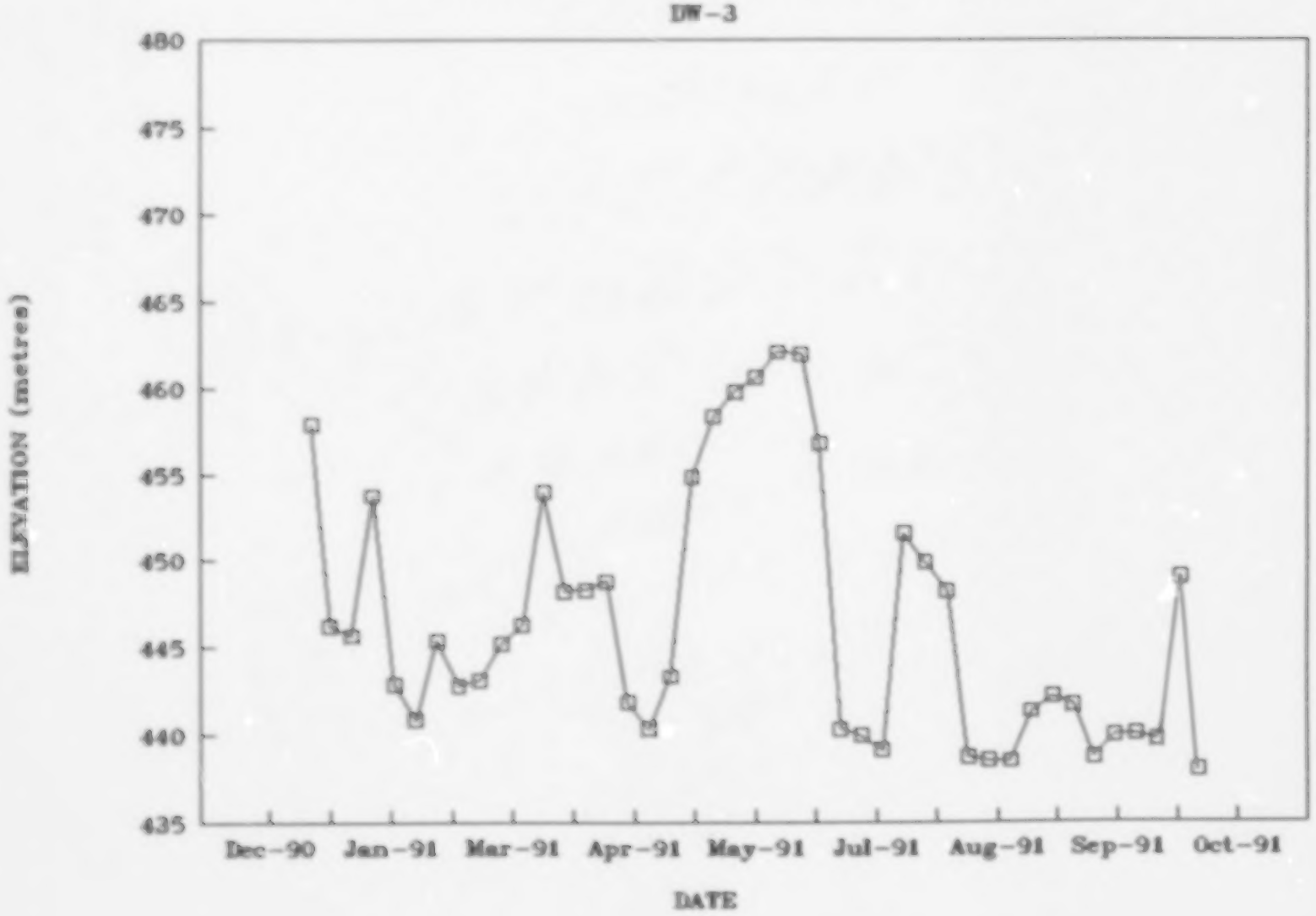


FIGURE D-35

Groundwater Elevations

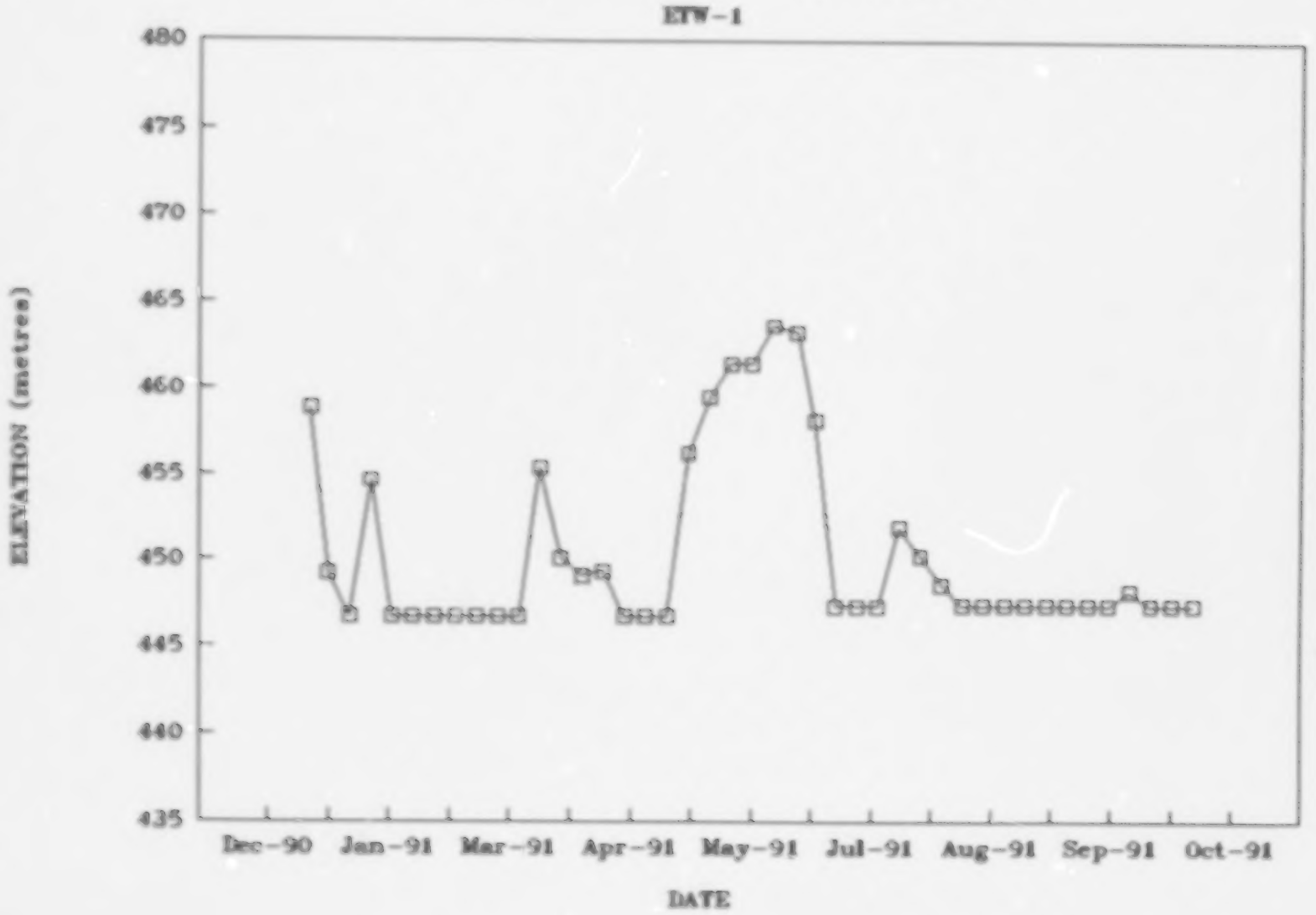


FIGURE D-36

Groundwater Elevations

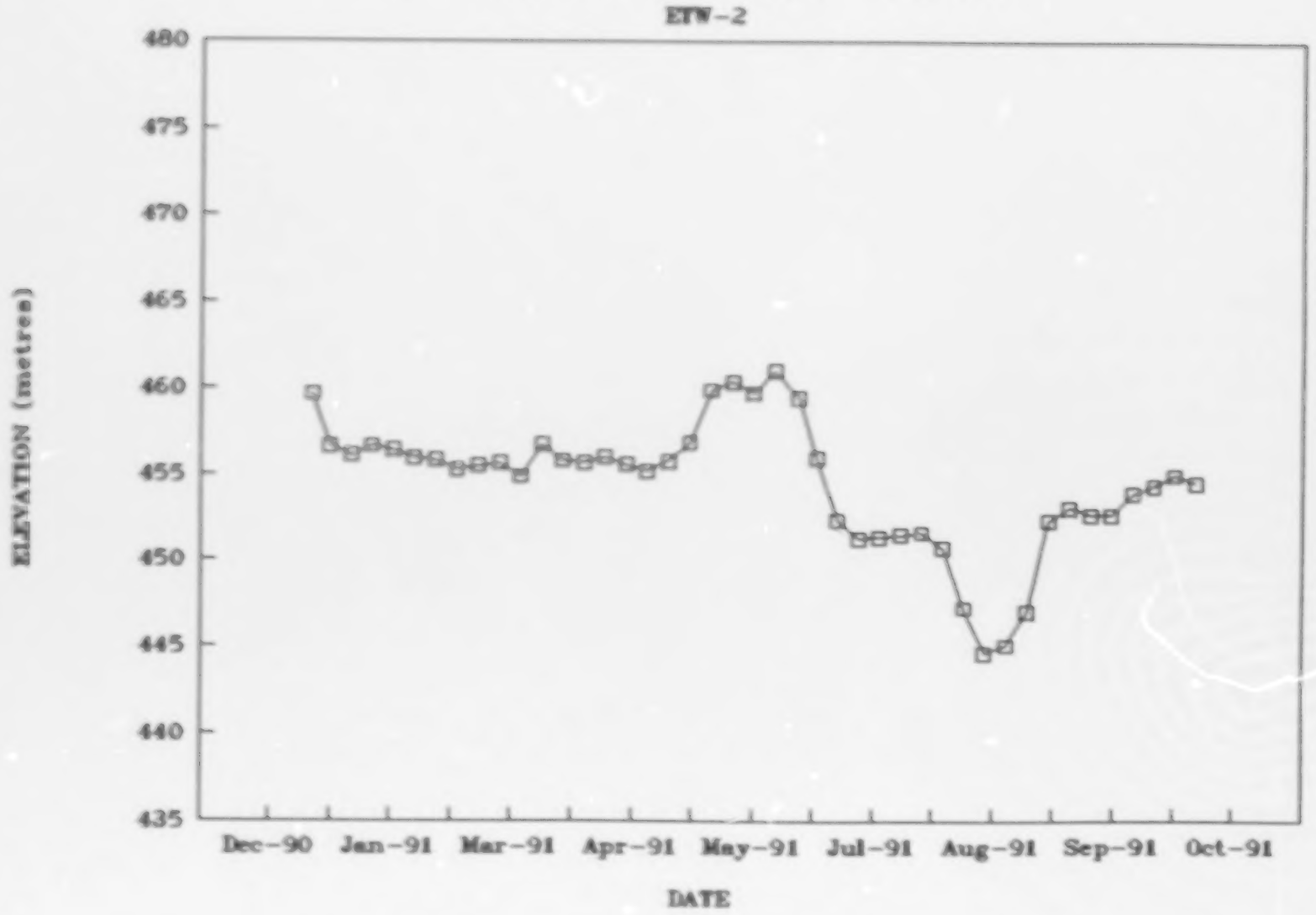


FIGURE D-37

Groundwater Elevations

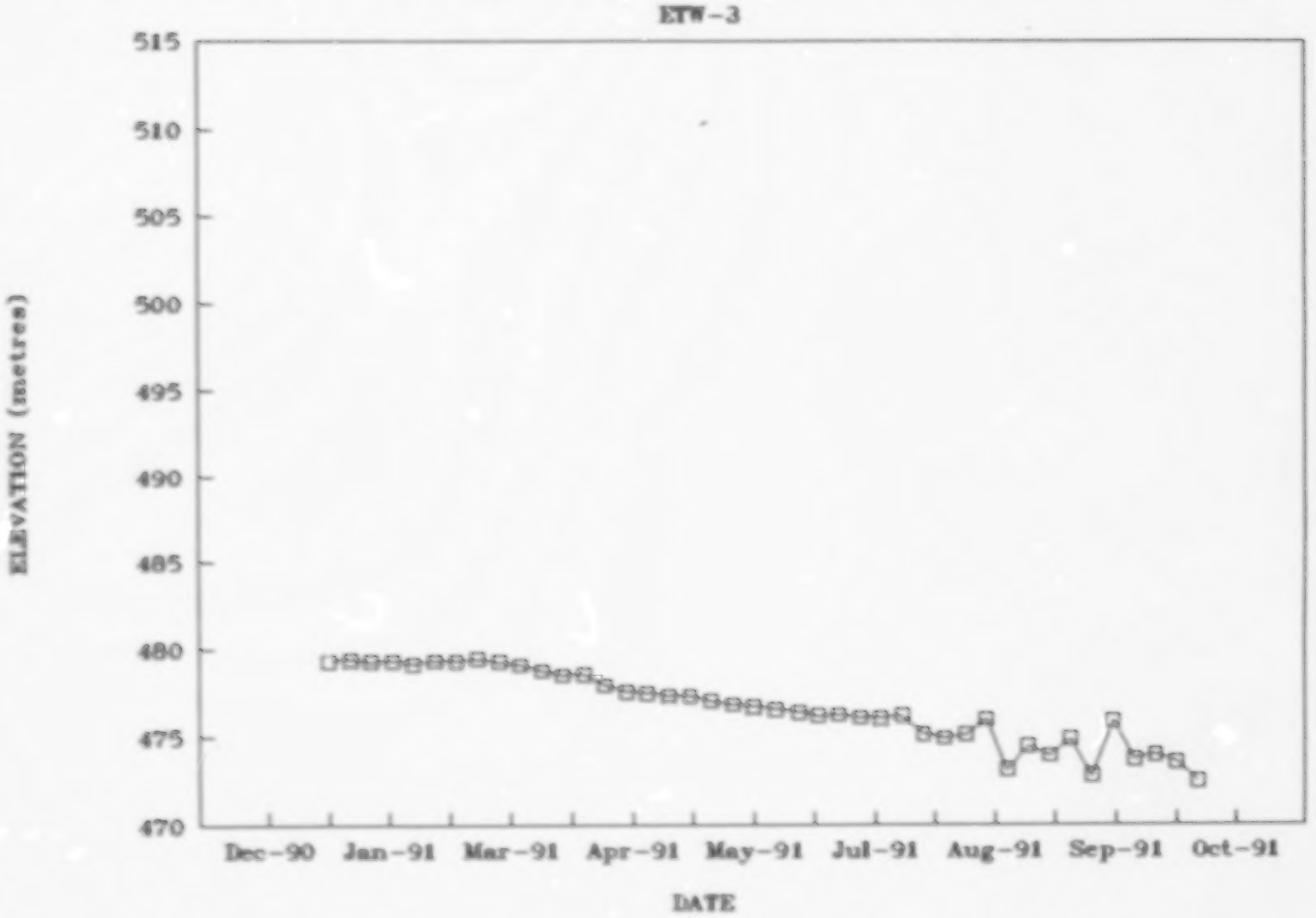


FIGURE D-38

Groundwater Elevations

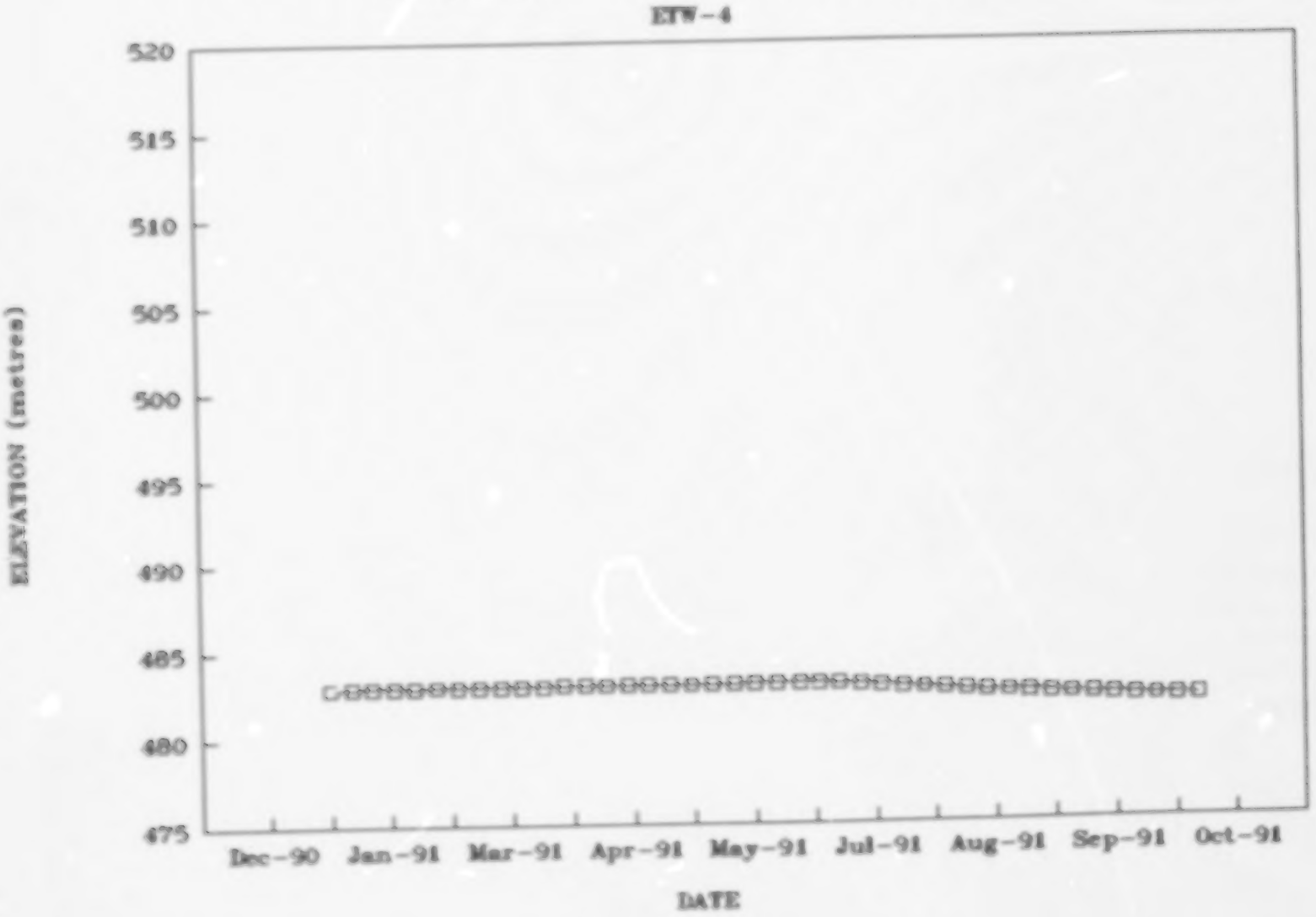


FIGURE D-39

Groundwater Elevations

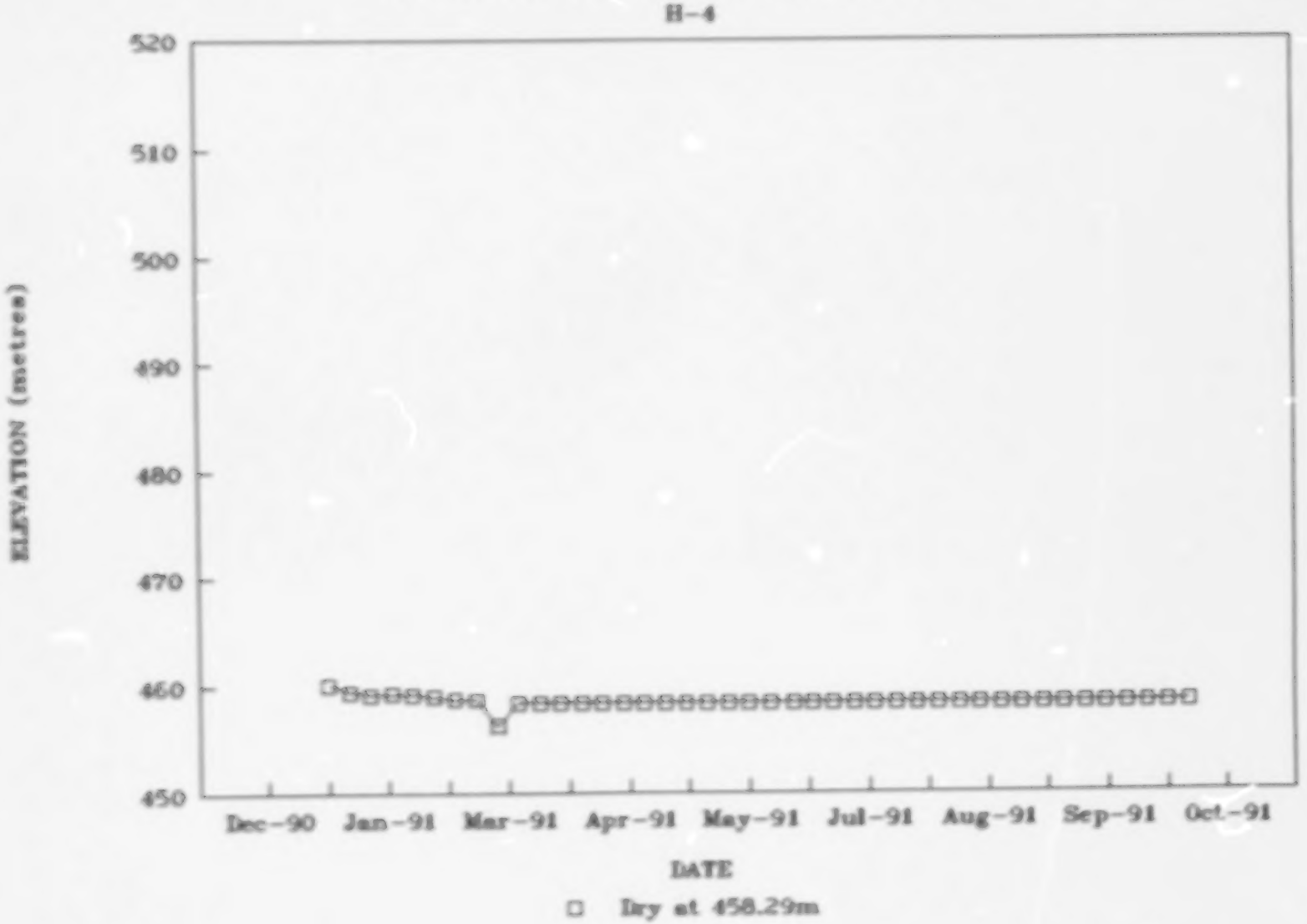


FIGURE D-40

Groundwater Elevations

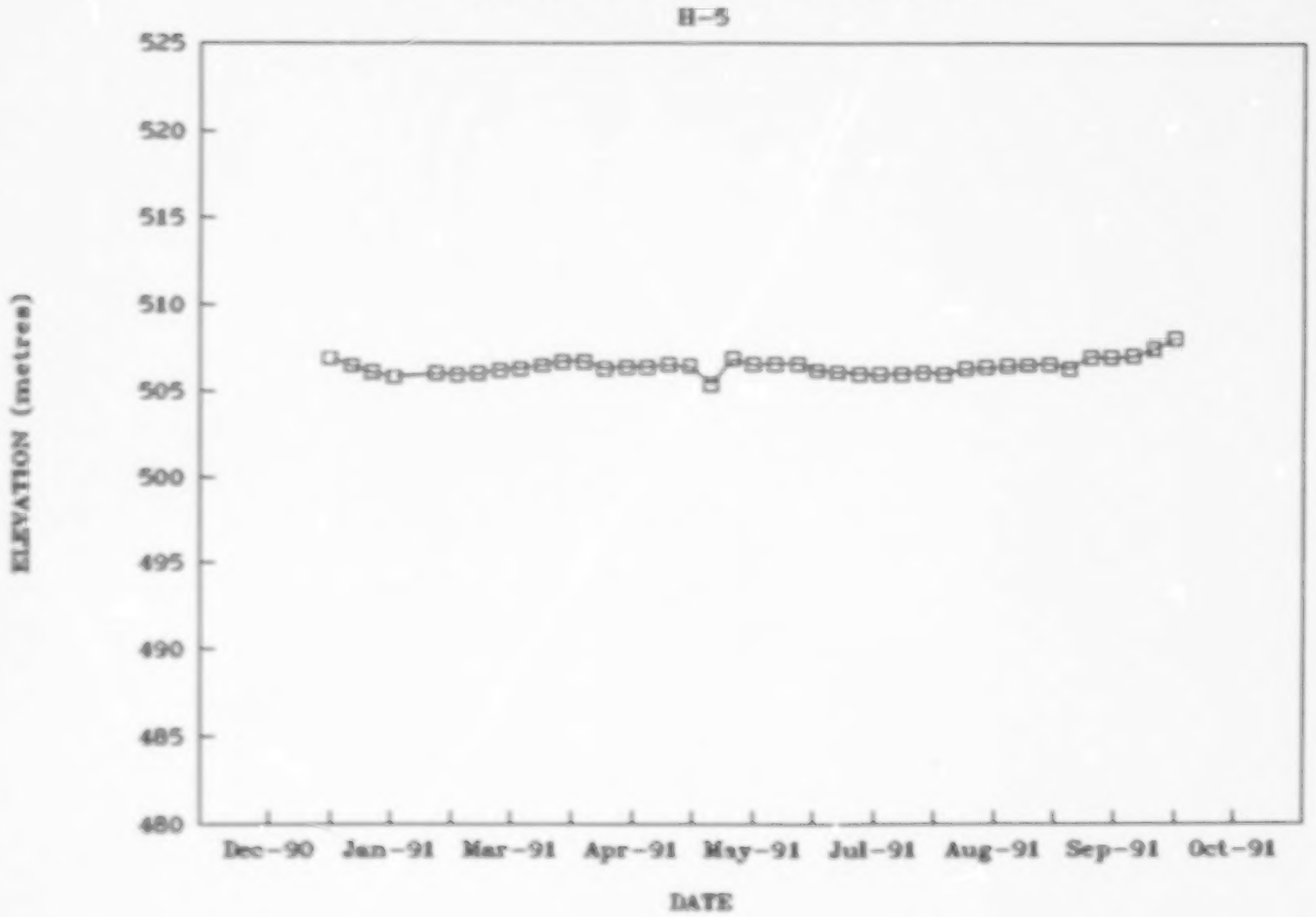


FIGURE D-41

Groundwater Elevations

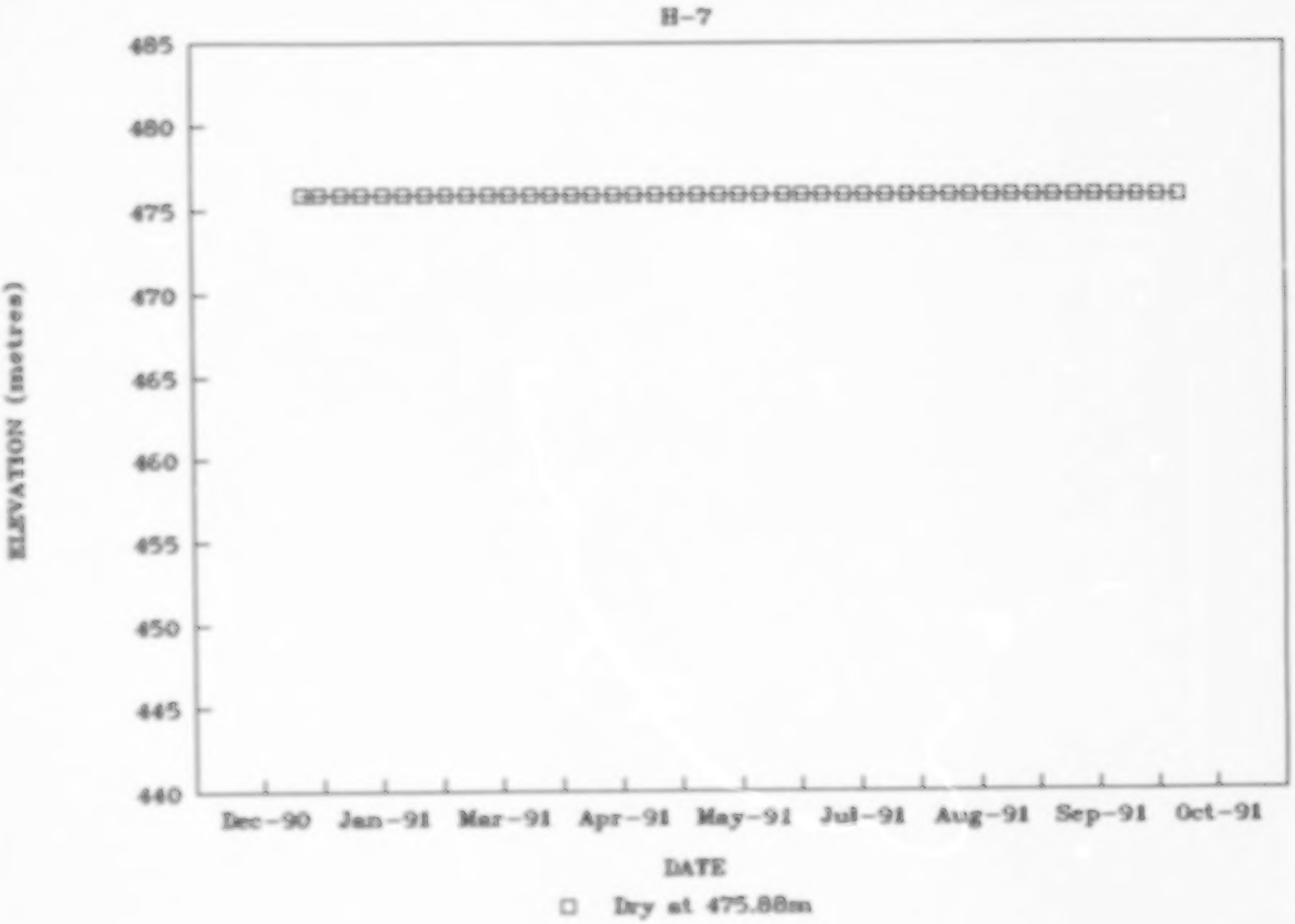


FIGURE D-42

Groundwater Elevations

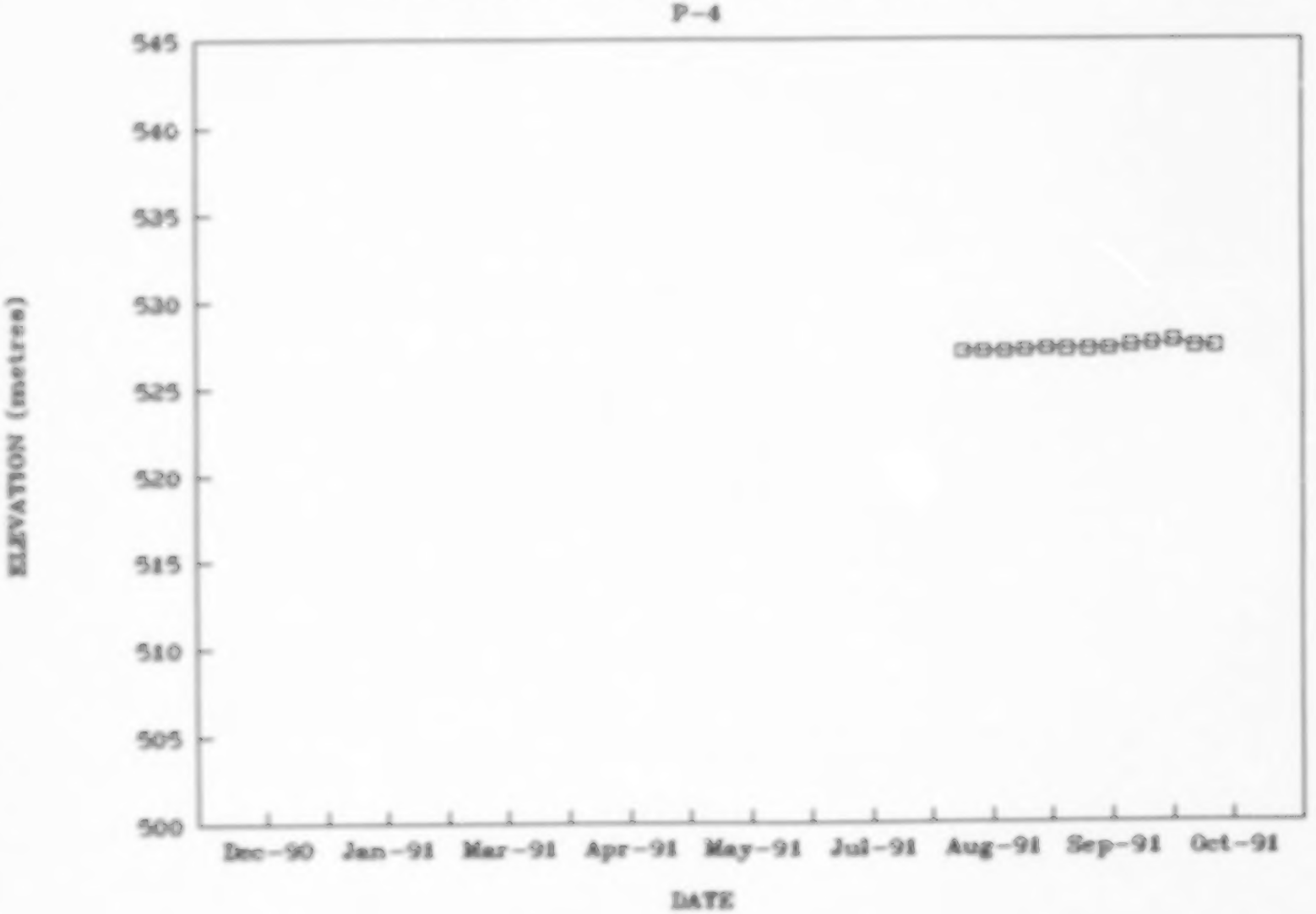


FIGURE D-43

Groundwater Elevations

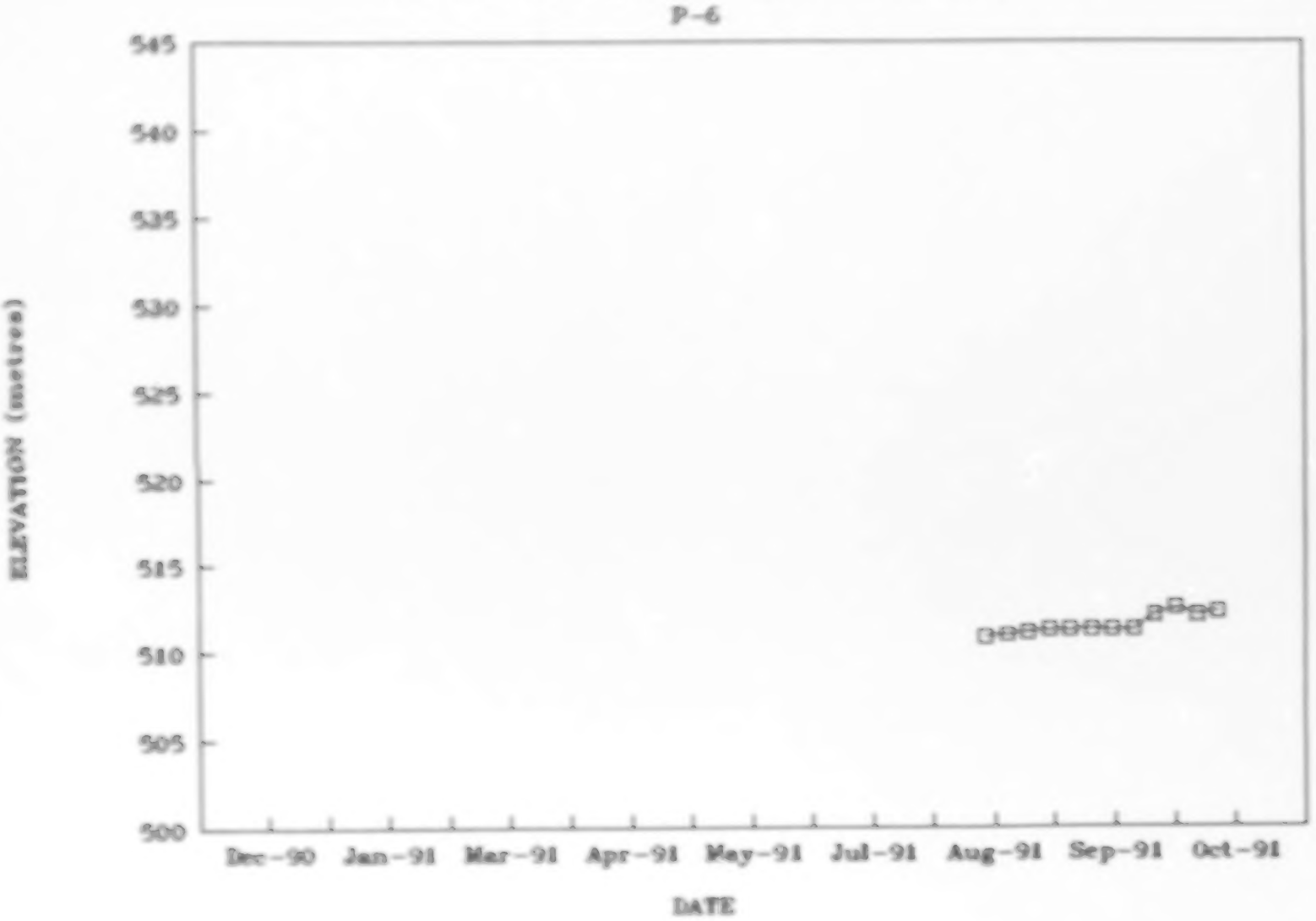


FIGURE D-44

Groundwater Elevations

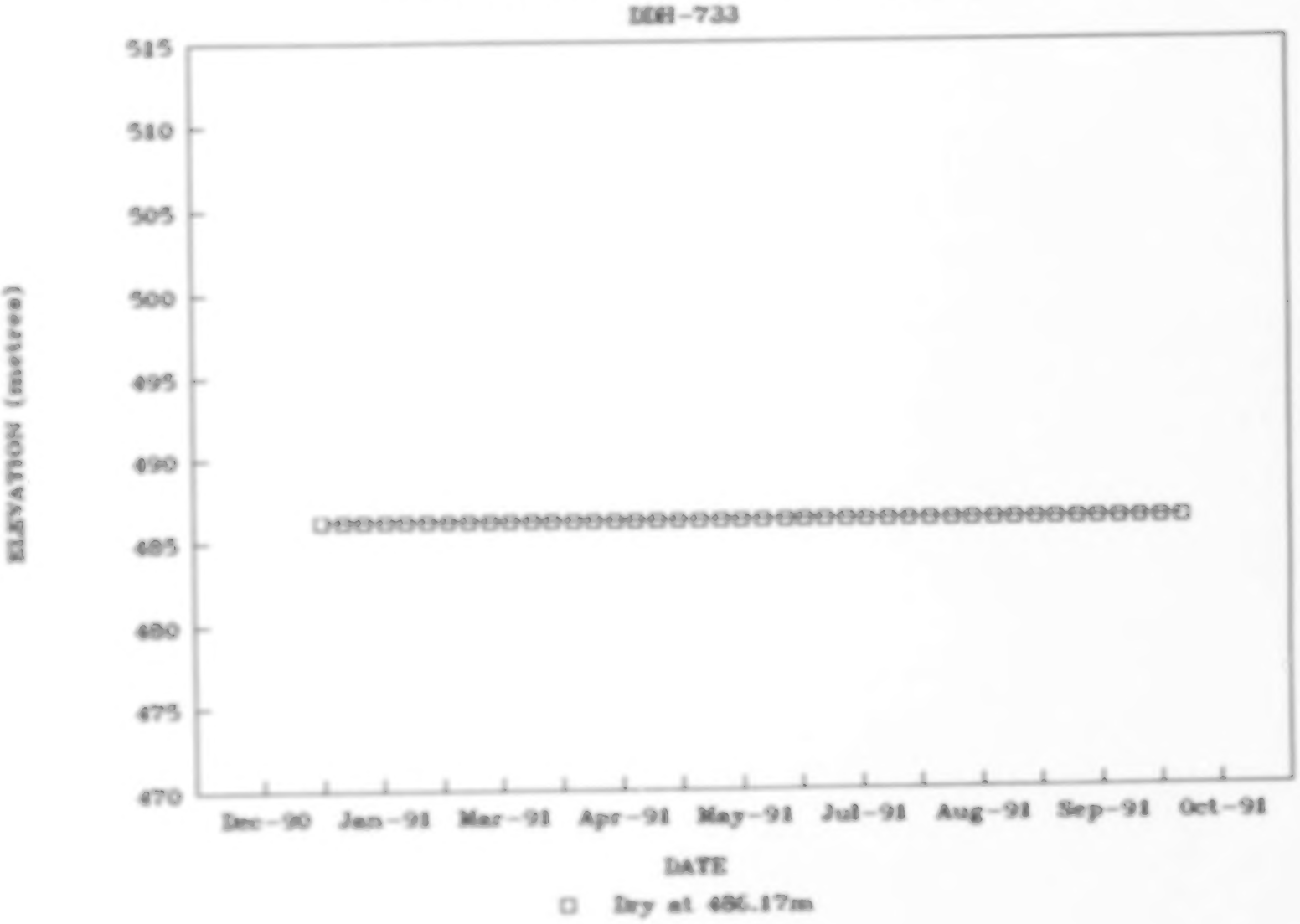


FIGURE D-45

Groundwater Elevations

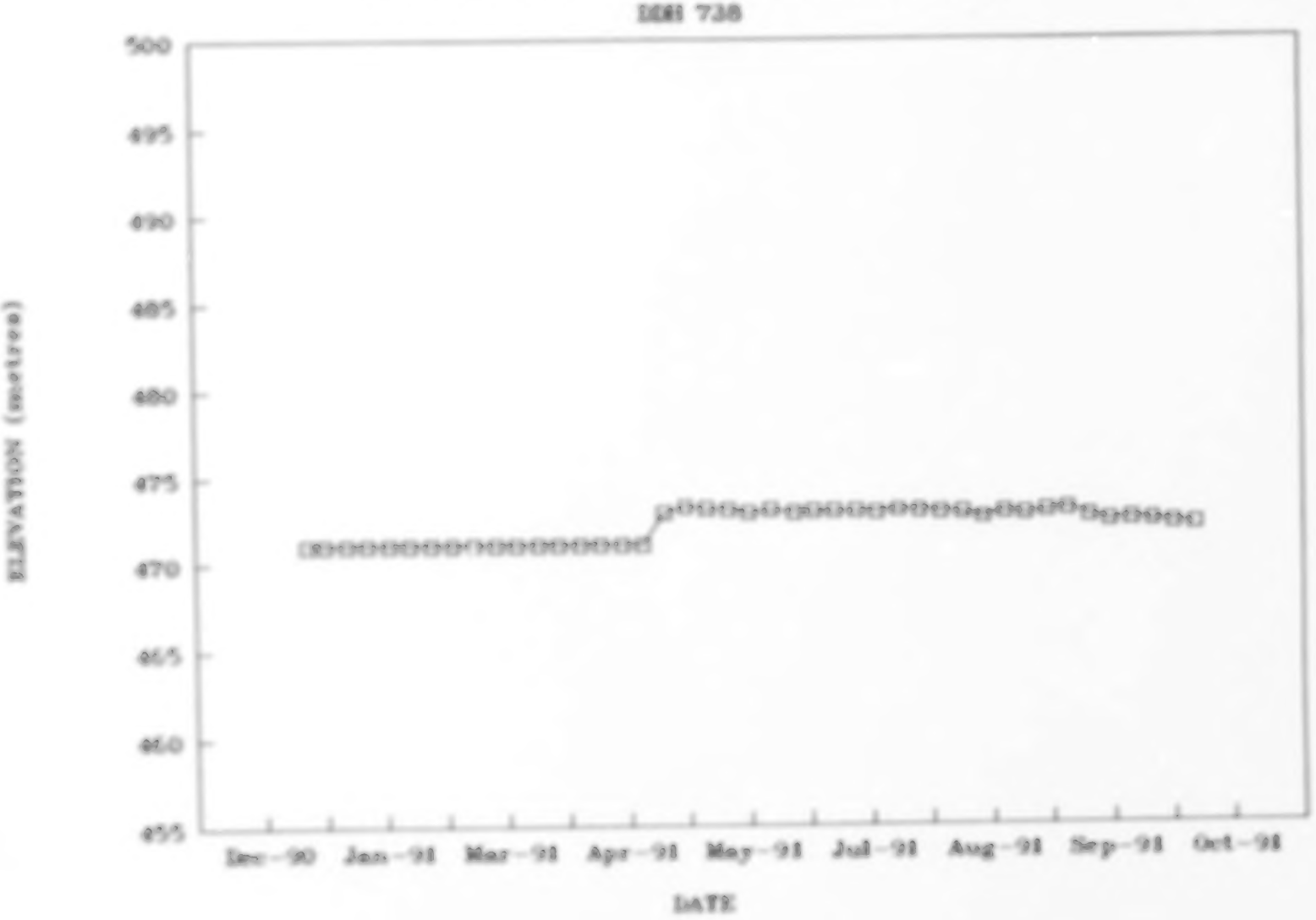


FIGURE D-46

Groundwater Elevations

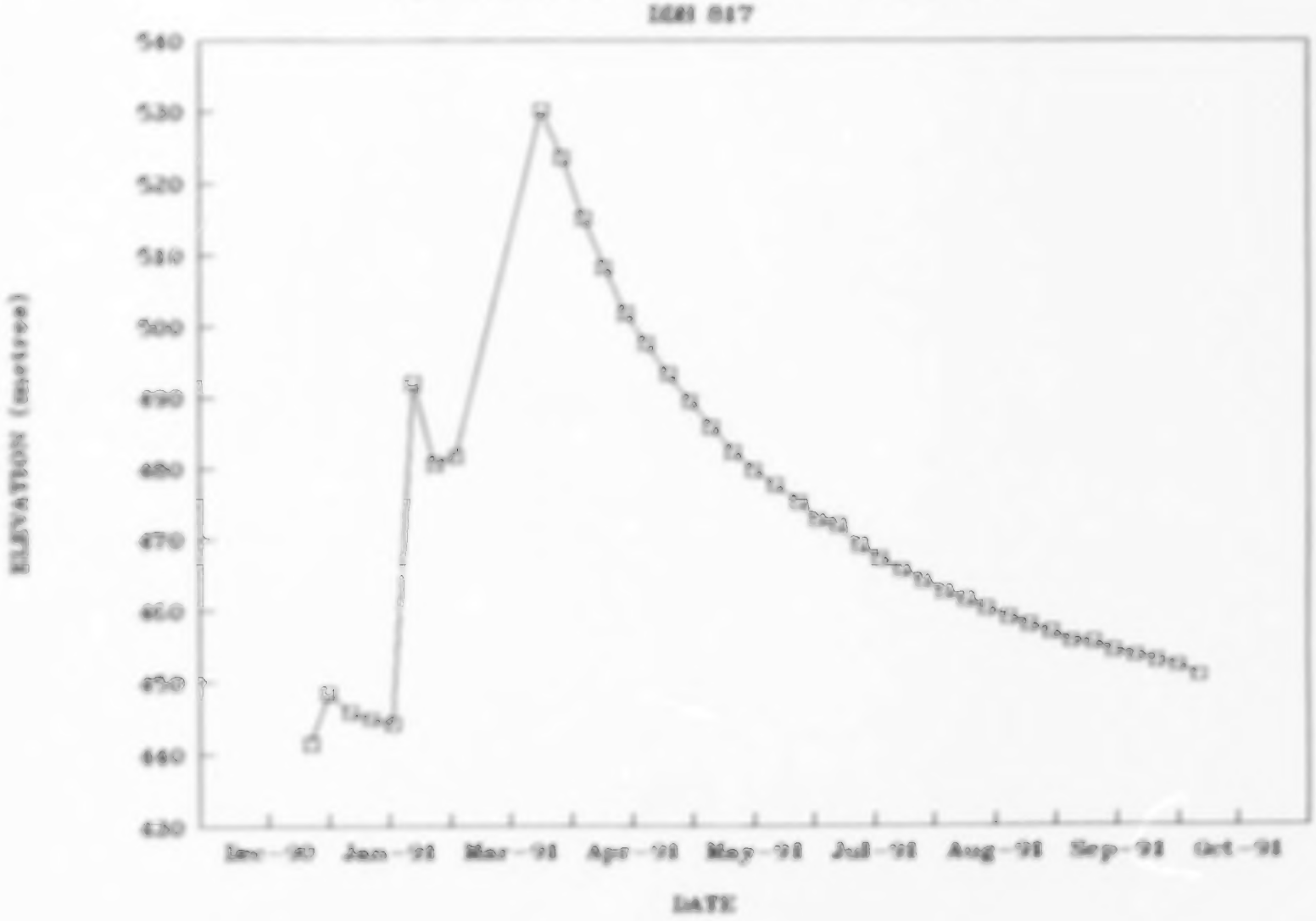


FIGURE D-47

Pressure Test Points

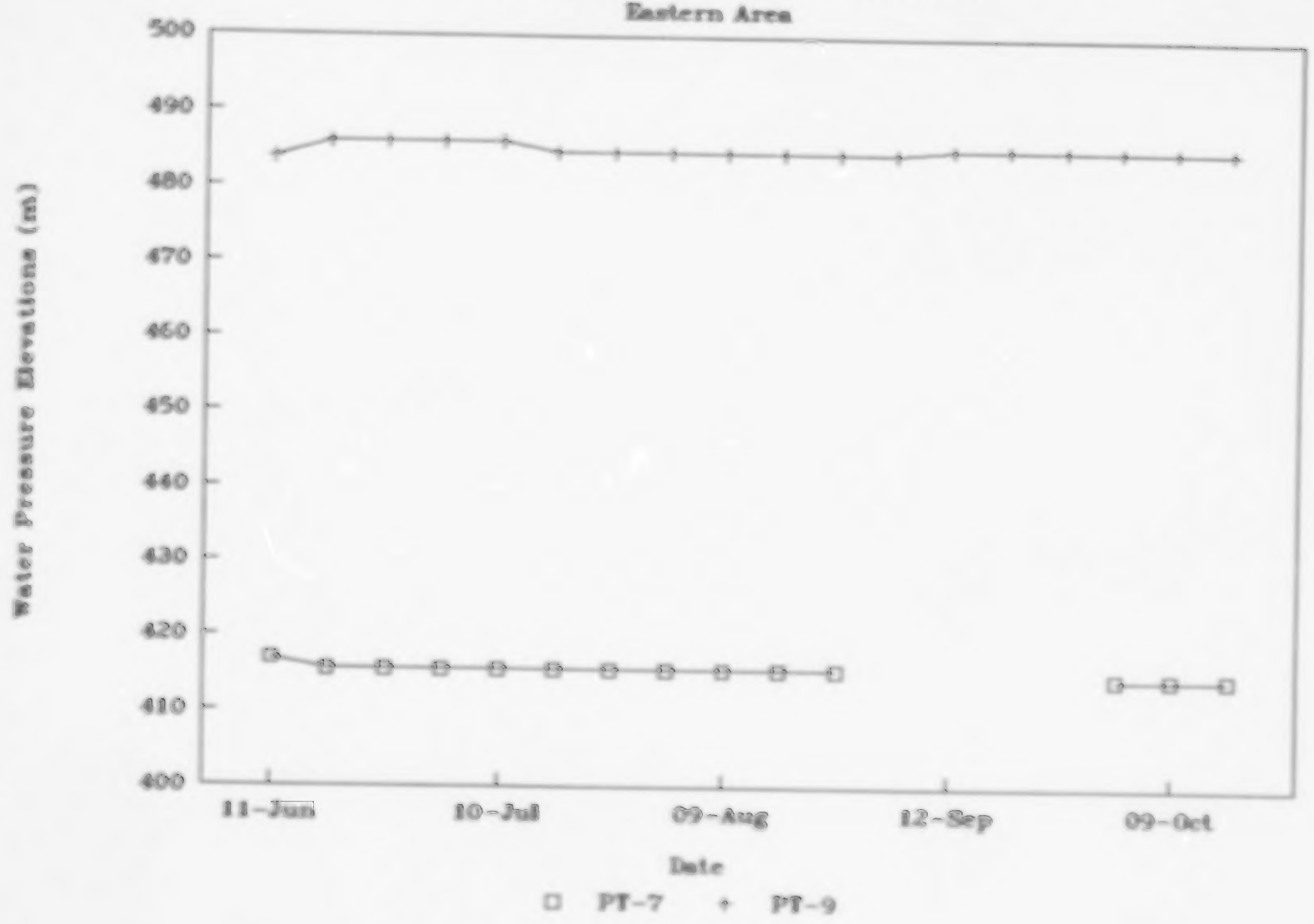


FIGURE D-48

Pressure Test Points

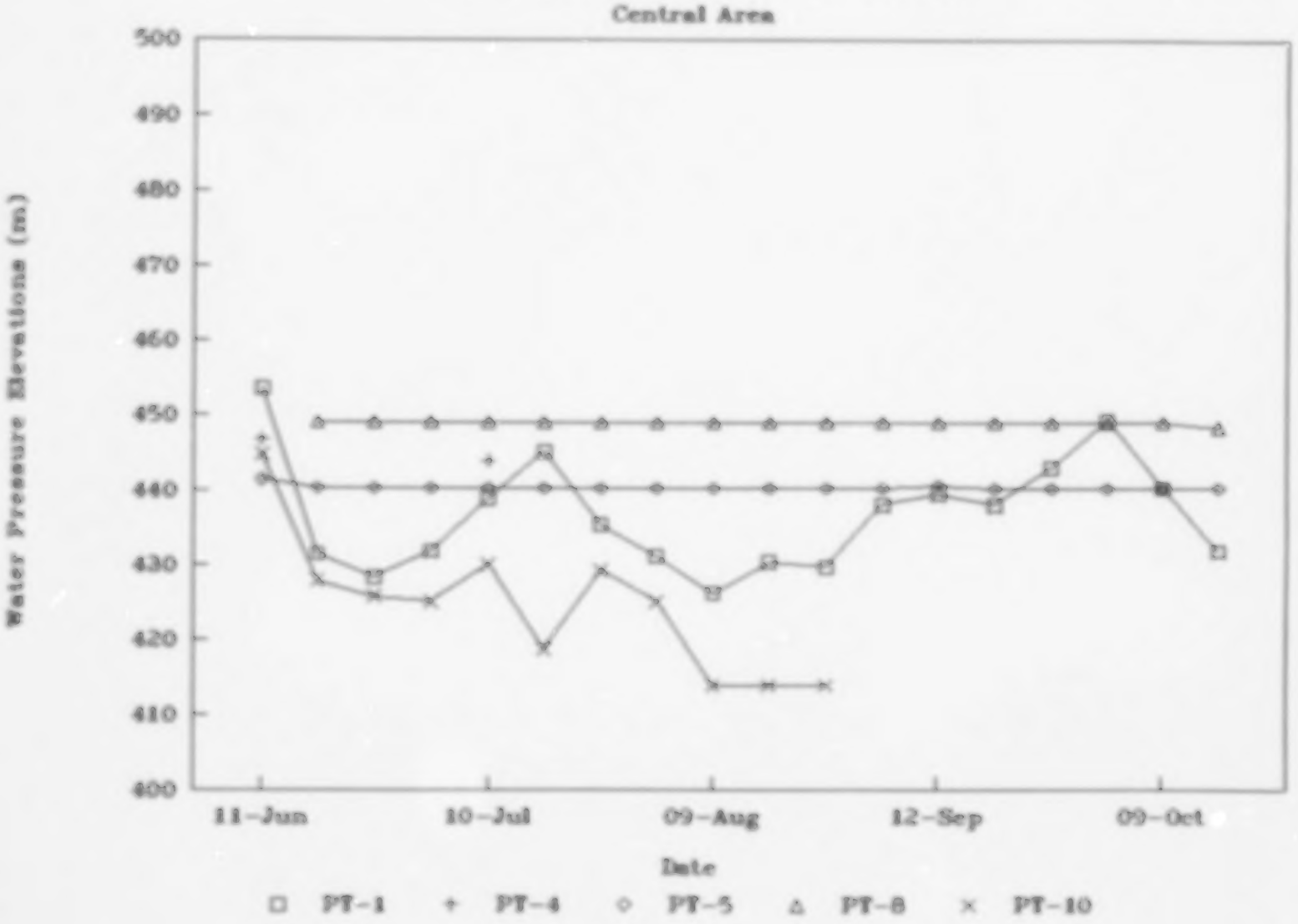


FIGURE D-49

Pressure Test Points

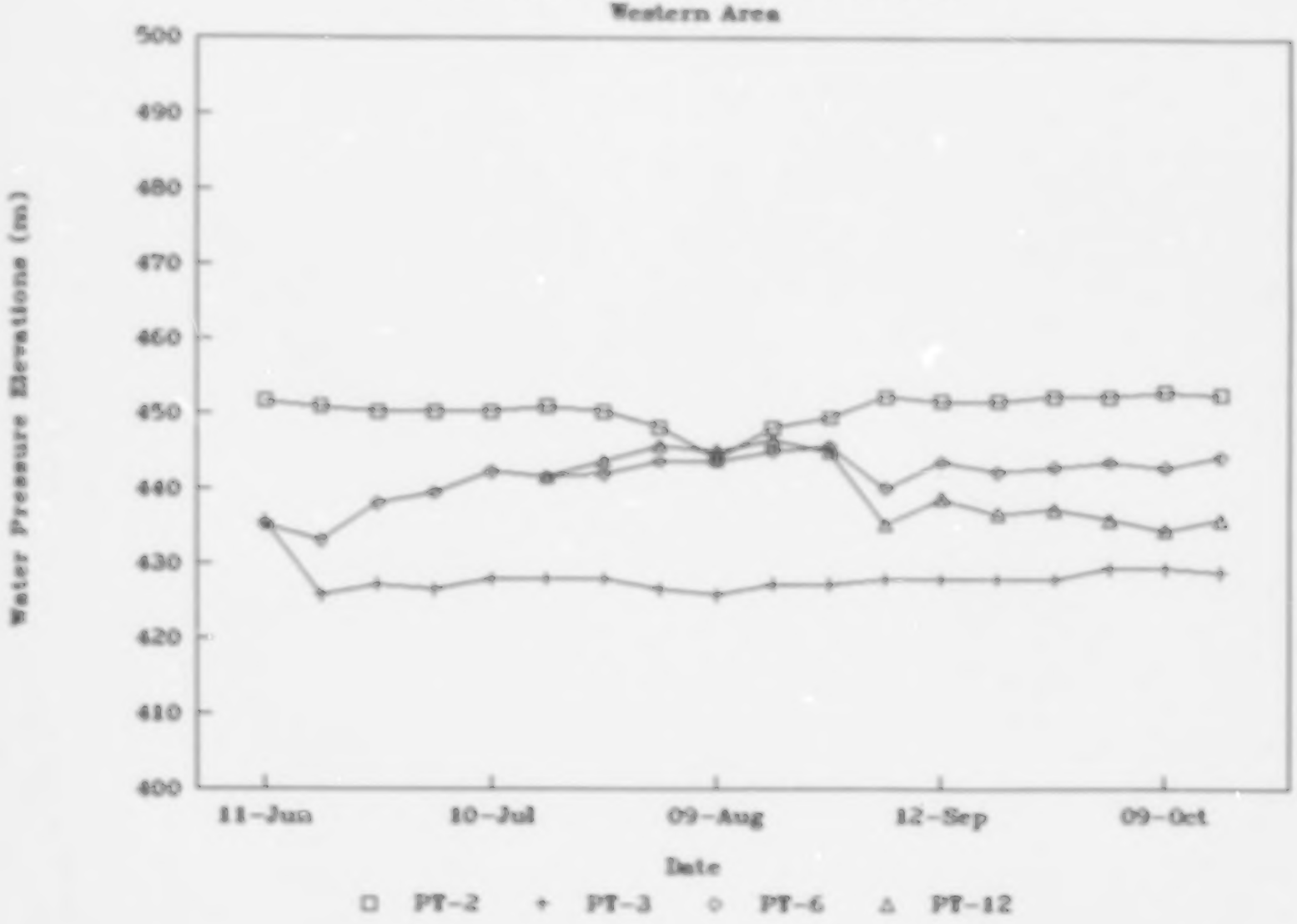


FIGURE D-90

MAPS
NOT
FILMED

CARTES
OMISES